HONI SOIT QVI MAL Y PENSE

A Ligh
To the Art o
GUNNERY.

Wherein the moſt nece ary points belonging to a Gun ner either in Sea or lan Service are made Practi ble, And faithfully ſet forth

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By Capᵗ. Tho. Binning.

A LIGHT
TO THE
Art of Gunnery,
OR
Sea-Gunner's Companion.

Wherein is laid down
The True Weight of Powder
Both for Proof and Action of
All Sorts of GREAT ORDNANCE.
ALSO
The True Ball, and Allowance for Wind.
With the moſt neceſſary Concluſions
For the Practice of GUNNERY,
Either in Sea or Land-Service.

By Capt. THOMAS BINNING, Mariner.

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To the Reader.

Judicious Reader.

I *Am perſwaded there are none, though but mean Artiſts that will queſtion the worth of the Art of Gunnery, being founded upon the two principal Pillars of the Mathematicks,* viz. *Arithmetick and Geometry. For by this Art, and good Artiſts, the Artillery hath gained Battels, Towns, Caſtles, Cittadels and Forts; yea, the ſtrong Trenches of a ſtrong Army forced, opened and ſtormed by the weaker Army, to the ruin of the Intrenched Forces; which was ſeen at the Battel of* Lutzen, *where the Serene and Potent* Guſtavus Adolfus *King of* Sweden *was killed; for there the* Swedes *Gunners did ſo artificially ply their* Ordnance, *that the* Swedes *Army ſtormed the Imperialiſts in the moſt ſecure Trenches that could be made, and a ſtronger Army within than thoſe without; and only by the Artificial and Induſtrious Carriage of the Gunners. By which you may perceive, that there is as much lieth on the uſing of the* Ordnance, *either by Sea or Land, to the ſafety of the Ship, Garriſon, or Army, and Annoyance of the Enemy, as upon any thing elſe.*

This Battel was at *Lutzen* in *November* 1631.

In this little Piece you may find the framing thoſe Draughts, the Calculating thoſe Tables for Powder and Ball, and laying out thoſe Height-Rules both for Powder and Shot, with the True Wind of every Gun, with the Dimenſions of their Fortifications, in giving Powder, not having regard at all to the Weight of the Peece; further, as for the Draught of the Ordnance, *likewiſe what is uſeful to a Gunner either by Sea or Land; Whereby I am perſwaded, any that will take notice of the uſe of the Quadrant and Quadrat, and Obſervations thereon, will find as Artificial Recreations in this little Piece, as in any hath been written hitherto on this Subject.*

It

To the Reader.

It is viſible the great harm that cometh by breaking Guns in firing, is the Ignorance of theſe Gunners, and the great allowance of Powder; for if a True-Fortified Peece of Ordnance ſhall have to 9 ℔ Ball 7 ℔ of Powder; the Queſtion is, What ought to be given to a Reinforc'd Peece ſhooting the ſame Ball? This and other ſuch Buſineſſes moved me to write, that thereby Gunners might be more circumſpect.

I have not done this, that thereby I may add any thing to the Artificial Gunner, but that the younger Brethren may, by reading and obſerving what is here made plain, learn to do their Duty.

If this Piece do inſtruct any yet Ignorant, I ſhall be glad; if it pleaſe the Readers fancy I have content; but if it diſpleaſe any critical obſtinate Maligner of the Art, I ſhall take no more notice of him, but deſire he may amend himſelf and this alſo; Nevertheleſs conclude as thou findeſt, and conſider the good will of *Thy Friend*, T.B.

To the Praiſe of his Country-Man Capt. Thomas Binning.

INto this little Book I plainly ſee
Inventions rare, with Art of Gunnery,
Grounded upon two Pillars that muſt ſtand,
While God and Nature Earth and Sea command;
Ar'thmetick, *Geometry*, with new Inventions,
Thy King and Countries Good, being thy Intentions;
Therefore *Minerva* claims Ingine and Wit,
And Mighty *Mars* does own this Subject fit.
Seeing from our Country-Man it doth redound,
(Whoſe Country hath been formerly renown'd)
Let us not keep from him deſerved Bays,
Which Strangers would afford as his due praiſe,
Becauſe he hath given a Light to Gunnery;
Not craving therefore Gold or other fee.
I do conclude, the like hath not been Wrot
In any Language till now by Scot.

Tho. Orquart.

AN INTRODUCTION TO THE GUNNER,

For his better Underſtanding.

THere are many who do intrude, and alſo that have obtained the preferment to be Gunners, either of Gariſons or Ships, who never underſtood any the meaneſt or leaſt Article (as I may ſay) in the Gunners A,B,C.

I ſpeak not this to diſcourage any from ingaging in the Employment of a Gunner; But I am ſure, except he be qualified with the Principles and Ground-Rules of Gunnery, he cannot be worthy of the place. And yet there is more than Art or Action to be obtained ere they begin: For which cauſe I will here begin with thoſe Qualifications, that a Man profeſſing and dignified with the truſt of a Gunner's place, ought to have.

1. That he be one that feareth God more than his Enemy.
2. That he be educated, and expert in his Profeſſion: for Experience confirmeth, ſome ſay, teacheth Art.
3. That he be Conſtant, and not given to Change.
4. That he be Faithful, True, and Honeſt.

An Introduction to the Gunner.

What a Gunner ought to be, to whom the Charge is committed, and what he ought to know.

As it is neceſſary in all Fortified Places, as well in time of Peace as of War, to have able practiſed Gunners, who are able to give an account with Reaſon, of the things belonging to their Charge, and that they be ſuch as fear God more than their Enemy; they ought to be honeſt, and not given to change, as afore is ſaid

The Gunner ought, beſides his true ſhooting, to be learned in Arithmetick and Geometry, which will cauſe him to give Advice where a Strength may be moſt conveniently battered, and what Ordnance is moſt fitting to accompliſh the ſame.

Alſo he ought to give Directions to the Engineer, what form of Batteries is moſt convenient at ſuch and ſuch places: Likewiſe that by his Art he give Directions that a Storm be made, where his Party may have the leaſt harm by his playing with Ordnance upon the places where danger is to be feared: likewiſe if in a Beleaguered Place, the Gunner is to defend the ſame againſt Oppoſition of the Enemy, and to order ſo, as by the aſſiſtance of the Ordnance, and by what other means he can, to oppoſe and deſtroy the Enemy for Defence of the Place.

But before all things, and before the Army approach to the Place, to which the Prince, General, or other Officer who commands in chief, do intend to beleaguer or take; It is neceſſary that the experienced Gunner be one to go before, and view the Place, with the Grounds thereby; the which to do, is beſt in the breaking of the day in the morning, to know if the Walls be ſtrong or weak, and how and by what means they may be brought down; as likewiſe to find if that Fort or Gariſon be ſo Fortified, as to annoy the Ground, or what part thereof is moſt ſecure for the Army to lay down Leaguer; and what Ground is beſt to annoy the Enemy moſt in the Gariſon, and alſo what place of the Walls thereof is beſt to Batter and Storm, and which way moſt ſecure to bring the Scaling Ladders to ſet up; and to know if there be any Mount, Steeple, or high Building within that is Fortified, to overlook the Leaguer; for by ſuch means great harm may occur, (or near the Leaguer) where the Enemy may overlook and relieve the Beſieged, and ſo cauſe the Leaguer to riſe; except the Ordnance in the Leaguer be capable preſently to diſorder and deface the ſame, that after the Leaguer is intrenched, it may be defended by Ordnance, *&c.* Then he muſt know if the Ground be diggable, and on what ſide of the Leaguer the Proviant may be beſt and moſt ſecurely brought in, and what freſh Water is there-about for their relief within command of the Leaguer-place: So when it is known where, on what end of the place or ſide the Great Ordnance muſt be placed, and lie from or in the Leaguer, then muſt the Batteries be drawn out and meaſured; and becauſe it is hazardous to work on a Plain, to break Ground before an Enemy, but there muſt Blinds be raiſed, ſome muſt be where you are not to work, as well as where you intend to build your Batteries: But if you be on ſuch Ground where you muſt begin your Approach at a diſtance, then you muſt know at what diſtance you may with conveniency break Ground to run your Trenches for Approach; and as it is certain the Point-Blank Diſtance of a Peece of Ordnance is 220, 230, 240, 250 Geometrical Paces, which is alſo the diſtance of a Muſquet-ſhot; Therefore the knowing Gunner ought to give the Workmen order, if there be no other Engineer for the Effect; and in this regard the Gunner ought to be acquainted in Surveying for this, as well as for his Batteries and Ordnance placing: For if one would begin an Approach, then he muſt chuſe out ſo many Souldiers uſed to Work, as may be able to defend themſelves and reſiſt a Sally, if any be: Not neglecting to have Parties both of Horſe and Foot about the Ground to defend them; in regard they are to carry, beſides their ordinary Arms, Shovels, Pickaxes, Gavelocks, Crows, and what is neceſſary for their Work. At the place commanded to break Ground, it is fitting to caſt up a Redoubt or two, from whence the Trenches are to begin; and run the Approaches, that if any ſuddain Aſſault come, the Workmen may retire thereto and defend themſelves, and work till they have aſſiſtance: for if the Workmen had no place of preſent Retreat, they would be forced to run and leave their Work, Tools, and Arms to the Enemy. To this purpoſe it is to obſerved, That the expert Gunner, or Engineer, who is employed in this Work, is to uſe all the Art, Skill, and Experience they have, to run their Lines in ſuch ſort, that thoſe which are in the Trenches and Approaches may not be diſcovered and ſeen by the Enemy, ſo that with ſafety and expedition they may approach near the place, or part of the Fortreſs, which the General deſires to become Maſter of.

For now in our Modern Fortifications, there are but two parts in a Town, or Fortreſs, of which one muſt be battered if they mind to take it in; and theſe are either a Bulwork or Curtain.

When the General or Commander of the Field, by advice of the Council of War, hath reſolved either to batter a Bulwork or Curtain, the Gunner or Engineer being preſent at the breaking of Ground, is to ſhew and inform the Workmen how they are to run their Line, and, as the occaſion preſents, of divers lengths; for they muſt be turned at every juſt occaſion, which is moſt neceſſary. When the Line is laid out and marked, the Workmen muſt be divided and placed in order, that one may not hinder another: Then to give to every Workman the length of 4, 5, or 6 foot, and then begin they to haſten into the Ground, for to avoid the danger which they are expoſed to, while they ſtand upon the Earth; Therefore the Earth which they dig, they caſt up before them, and as faſt as can be make a Hole like a Grave; ſo when they have digged three foot in the Ground, and three foot broad, then ſure they are covered, ſince from their Baſis to the top of the Caſt-up-Work there are ſix foot: When they are under Covert, then they enlarge and deepen the Approaches as they are ordered: Obſerve, they need not be ſo deep at the beginning as near to the Fortreſs; ſometimes the Trenches muſt be made ſo broad, as that the Canons and Wagons of Proviſion muſt be drawn to the Batteries or Galleries. Theſe Works are ordinarily begun in the Night, ſo when the Night is gone, there are freſh Men ſent to relieve the firſt, and enlarge the Night-work, and amend what they could not ſee wrong. After this Nights Work, or the ſame, there are Corps of Guard made to contain Souldiers for a Main Guard, which Work ought to be with a Line of Communication with the Trenches, though they be at a diſtance, *viz.* four or five paces diſtance. When one Line is finiſhed as aboveſaid, and that it muſt be run no further that way, the Gunner or Engineer turns it another way, bearing it from the Town or Fort, and placing the Workmen as aforeſaid, and ſo continuing by Turnings and Windings, till he hath got ſomething near the Place or Fort beſieged, and making good the Line continually with Corps of Guards and Batteries, until they be at the brim or ſide of the Moat or Ditch of the Fort: Then is the Gunner or Engineer ſo to order his Buſineſs, as to begin a Sape or Gallery, or Mine under the Ground, directing his Courſe by his Compaſs: as if Impediment of Rocks happen to ſtop his Courſe intended; he may make ſuch Lines and Angles about the ſame, as may bring him to his direct Line again; no reſemblance to it, but a Mariners Traverſe by croſs Winds at Sea.

But for the effectuating of a Mine, there muſt be proviſion made of divers things neceſſary thereunto; as Shovels, Spades, Pickaxes, and all kind of Maſon-Tools, with all things requiſite to pierce a Wall, wherewith the Rampier is made: Then one prepares Props to ſupport and bear up the Mine from falling or ſinking, being thick and long, as is requiſite; Likewiſe you muſt have ſtore of Fir-Planks to line the Mine within that it may not fall down, for it muſt all be lined if the Ground be fruſh or brittle.

Before you begin to make a Mine, it will be requiſite you know the Ground of the Place, whether it be vaulted or not, or on what the Foundation thereof is laid: The Miners being to break into a Wall, are to carry their Mines as cloſe and ſecret as may be, that the Beſieged may not hear any noiſe, or get any notice where the Mine is made, and how it runs; for if they do, queſtionleſs they will make a Contra-Mine or Traverſe above Ground, to diſcover and ſpoil your Mine begun; ſo that failing, you cannot force the Beſieged that way, except you begin a new Mine in another place.

The Maſter-Gunner or Engineer that conducts a Mine, ought to be a Man of good Experience, leſt he miſcarry in his Traverſe; for which cauſe, he ought to be well acquainted with the Mariners Compaſs, and alſo with the Variation thereof; for if there be a Mineral of Iron-Ore in that Ground, it is like the Compaſs will vary, and ſo miſcarry the Mine: He ought alſo, for his Lines of Traverſe, to be acquainted with the Line of Chords, or Plain-Scale; otherways with the uſe of the Protractor, for directing his Courſe and Traverſe in the Mine, that he miſtake not himſelf either in his Courſe or Diſtance, Altitude or Profunditude, according to the Ground he works in, and the Foundation of the Rampart. When the Mine is brought to the entry of the place where the Chamber muſt be: Sometimes order may be given to blow the Rubbiſh into the Fort beſieged, or it may be out, into the Moat or Ditch; either which may be done by making the ſide thinner, which they would break to, than the other: And our Experience is ſufficient proof of this, either in Cannon or Muſquet; for if you load a Peece of Ordnance, that there be a greater weight put after the Powder than in reaſon, give fire to the Touch-hole, and you will find that Peece fly out either at Side or Breech.

The proportion of Chambers are various as the Wall or Rampart which they are to deface, therefore can have no dimenſion, but they muſt be made ſo large as to contain Powder ſufficient. Some would preſcribe Rules for a Barrel of Powder to blow up a Rod of Earth; but the Earth being of various Ponderoſity, and ſome ſo much ſtronger bound than others, that I ſuppoſe they muſt uſe rather more than leſs Powder; yet the Chamber would not be made larger than to contain the quantity of Powder ordained to open that Breach.

When an Enemy hath beſieged a Place, Citadel, Fort, Caſtle, or other Fortification, and hath approached to Batteries; certainly it behoves the Beſieged to look about them, and to do their utmoſt endeavour to hinder the Enemy. The Defence againſt theſe Approaches is, to ſtrive to make ſome Contre-Approaches; which may be done by ſtoutly ſallying out, but withal, to ſally out with diſcretion, for fear of loſing Men, which is to be expected; (but no *Dondaſs* for Governour, who would neither permit ſally, nor great Gun or Muſquet to be fired againſt the Enemy:) by which ſallying, the leaſt Offence you do the Enemy is to hinder the progreſs of their Approaches; for if they be beat back, and conſtrained to fly into their Works, for ſo long as the Alarm endureth, they cannot advance their Work, nor begin again to Work till the Beſieged be retreated.

Likewiſe this Manner of Defence may be made by Cannon, which may play from all places upon the Workers of the Approaches, to do them what harm Imaginable, which may put the Workmen in fear, by ſeeing their Fellows miſerably ſlain by the Cannon, which may be a means to make them leave working till there be Batteries made againſt the Beſieged.

The Contre-Approaches, by which you reſiſt an Enemy, that they may not become Maſters of your Outworks, or Contre-ſcarſ, with their Approaches; Theſe Contre-Approaches, to hinder the Enemy in their approach, are made by caſting up ſome Traverſes, and running them ſo, as to find the Enemies Mines; Theſe Lines of this Traverſe muſt be caſt up toward the Enemy, but left open to the Beſieged, or Gariſon, becauſe by them they muſt be defended: This Traverſe muſt be ſo made, that it give no advantage to the Enemy if they take them in; and be ſure they may be flanked both with Cannon and Muſquet from the Fort or Gariſon.

So that as there is an Offenſive War, there is alſo a Defenſive War, as doth appear by Mines; for the Beſieged having diſcovered them, and got into them, may lawfully kill the Miners: Now when the Beſieged have found the Mine out, it is to be known how they may make the way clear before them, and either kill the Miners, or make them fly, without having the leaſt harm.

For the Gunners further Knowledge, that is yet in his Minority, this Work is begun with *Decimal Arithmetick*, which is very uſeful in the Art of Gunnery, the Working and Extracting of the Square and Cube Roots; as alſo ſome Definitions and Problems of Geometry: by which the Gunner may the better make uſe of his Compaſſes, for which he will have ſeveral needful uſes; for the whole Matter, I know little in this Book that may be wanting in a Gunner, that may be called a ſufficient Gunner. In fine know, that I ſhall be glad that every Gunner may profit by it, and I wiſh that ſome may amend it. However know, that I intend this for your profit and the publick Good; Committing the Book to thee, and thee to God Almighty.

I remain Yours, &c.

Decimal Arithmetick.

CHAP. I.

Definitions.

A Fraction or broken Number, is a Number leſs than an Unite, or One; and according to the common way of Fractions, is expreſſed by two Numbers ſet one over the other with a ſmall line, thus, $\frac{1}{4}$; the upper Number is called the Numerator, and the lower the Denominator.

The Denominator ſheweth into how many parts the Unite or Whole of any thing is to be divided.

The Numerator ſheweth how many of theſe parts are ſignified by the Fraction.

A Decimal Number is that which is expreſſed by an Unite, with a Cipher, or Ciphers, as 10: 100: 1000: 10000: 100000: *&c.*

A Decimal Fraction is that whoſe Denominator is a Decimal Number, as $\frac{3}{10}$: $\frac{46}{100}$: $\frac{728}{1000}$: $\frac{2142}{10000}$: $\frac{57682}{100000}$: *&c.*

Decimal Fractions, whether they ſtand alone, or be joined with Integers, have always a Comma, or a ſmall Rectangular Line before them, to diſtinguiſh them from Integers, which is therefore called a Separating Line, as ,4, ,36, ,348, 4,2, 490,086, *&c.*

As in Integers the Value or Denomination of Places do increaſe by Tens, from the Unite place towards the left hand: So in Decimals the Value or Denomination of places do decreaſe

creaſe by Tens, from the Unite place towards the right hand: As in the Table following.

The Table.

9.	8.	7.	6.	5.	4.	3.	2.	1.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
Thouſand Millions.	*Hundred Millions.*	*Ten Millions.*	*Millions.*	*Hundred Thouſands.*	*Ten Thouſands.*	*Thouſands.*	*Hundreds.*	*Tens.*	*Units.*	*Tenths.*	*Hundredths.*	*Thouſandths.*	*Ten Thouſandths.*	*Hundred Thouſandths.*	*Millionths.*	*Ten Millionths.*	*Hundred Millionths.*	*Thouſand Millionths.*

In Decimal Fractions, the Numerators are only ſet down, without the Denominators; but the Denominators are eaſily known, for they are the ſame with the Denomination of the laſt Figure of the Numerator. As in the Examples following.

Examples.

,6 is { Six. Numerator. / Tenths. Denominator. } The common way $\frac{6}{10}$.

,42 is { Forty two. Numerator. / Hundredths. Denominator. } The common way $\frac{42}{100}$

,364 is { Three Hundred ſixty four. Numerator. / Thouſandths. Denominator. } The common way $\frac{364}{1000}$.

CHAP.

CHAP. II.

Addition and Subduction in Decimals.

ADdition and Subduction in Decimals, whether in pure Decimals, or in Integers mixt with Decimals, differ not from Addition and Subduction in Integers, only care muſt be had to place the ſeparating Lines of the Numbers under one another; as alſo the places of like denomination under one another; and the ſeparating Lines of the Sum or Difference, muſt be placed under the ſeparating Lines of the Numbers added, or ſubducted. See the Examples.

Examples in Addition.

,347
,268
,149
,764

,8972
,643
,8
,79
3,1302

346,98
74,2
6,934
,8
,07
428,984

In Addition and Subduction, let the place of the Fraction remain ſo many places as they were, and no more.

Example.

Addition.

35,72
78,05
113,77

Subduction.

78,25
35,75
42,50

Examples in Subduction.

,724	,89	,6427	64,279
,482	,5796	,36	48,384
,242	,3104	,2827	15,895

46,2	59,872	74,0	34,2
9,746	6,9	65,98	,642
36,454	52,972	8,02	33,558

CHAP. III.

Multiplication in Decimals.

THE Numbers to be multiplied together, are called Factors; and the Number found out by Multiplication, is called Product.

Multiplication, whether in pure Decimals, or in Integers mixt with Decimals, is the ſame in Operation with Multiplication in Integers: The laſt Numbers of the Factors muſt be ſet one under the other, as if they were Integers, not regarding the placing of the ſeparating Lines under one another, as in Addition and Subduction: And from the Product muſt be cut off with a ſeparating Line ſo many of the laſt Figures, as there are places of Decimals in both the Factors.

Examples.

,642	4,27	,489	50,4
,54	3,4	62	2,4
2568	1708	978	2016
3210	1281	2934	1008
,34668	14,518	30,318	120,96

If it happen, when the Multiplication is ended, that there be fewer Figures in the Product, than there are places of Decimals in both Factors (which may often occur when the Product is a Fraction) in ſuch caſe, as many places as are wanting, ſo many Ciphers muſt be prefixed to the Product on the left hand thereof, and then a ſeparating Line muſt be prefixt to ſign the Product ſo increaſed for a Decimal.

Examples.

,0375	5,525	12,653
,025	,0026	,00045
1875	33150	63265
750	11050	50612
,0009375	,0143650	,00569385

In Multiplication with Fractions, cut off ſo many places as there are Figures of the Fractions, in the Mulplicand and Multiplier.

Examples.

320,5	732,05
4,37	26,37
22435	512435
9615	219615
12820	439230
1400,585	146410
	19304,1585

CHAP. IV.

Diviſion in Decimals.

DIviſion, whether in pure Decimals, or Integers mixt with Decimals, is the ſame in Operation with Diviſion in Integers. But care muſt be had to give a true denomination to the firſt Figure of the Quotient; (according to this Rule.)

The Rule.

The firſt Figure of the Quotient is always of the ſame denomination with that place of the Dividend, which ſtands, or is ſuppoſed to ſtand over the Unite of the Diviſor.

It will happen ſometimes, that the Unite place of the Diviſor will ſtand beyond all the ſignificant Figures of the Dividend, towards the right hand, or towards the left. In this caſe you muſt put Ciphers to the right or left of the Dividend, until you come over the Unite place of the Diviſor.

As for Example.

If 3,47 is to be divided by 0,000462, they muſt ſtand thus;
0,000462) 0003,47 (
And the denomination of the firſt Figure of the Quotient will be thouſands of Integers.

Another Example.

If 34 is to be divided by 642,79, they muſt ſtand thus;
642,79) 34,0000 (
And the denomination of the firſt Figure of the Quotient will be hundreds of Decimals.

Note, That what Ciphers are added to the right hand of the Dividend, immediately next the Integers muſt have a ſeparating Line (or a *Comma*) before them.

In Diviſion, the Fractions being equal, the Work is as whole Numbers are.

If unequal, add ſo many Ciphers to the Dividend, as the Fraction of the Diviſor exceedeth the Fraction of the Dividend in places, that you may find your Fraction in the Quotient.

Examples.

26,37)732,05(27,76
5274.
20465
18459
20060
18459
16010
15822
··188

3,65)973,25(266,60
730··
2432
2190
2425
2190
2350
2190
·160

Other Examples.

52,75)954,00(18,08
5275·
42650
42200
45000
42200
2800

Becauſe the Fraction is two Figures in the Diviſor;
Therefore I add two Ciphers to the Dividend.
As in this third Example.

If in Diviſion I be to divide by a great many Figures, I may make a Table for them

Example.

Example.

Which is done, firſt doubling of it, then adding it until nine times, if I will ten, which proves it.

```
52,678)62794,000(1192,0346
       52678 ...
       ---------
       101160
        52678
        ------
        484820
        474102
        ------
         107180
         105356
         ------
          182400
          158034
          ------
           243660
           210712
           ------
            329480
            316068
            ------
             13412
```

1	52678
2	105356
3	158034
4	210712
5	263390
6	316068
7	368746
8	421424
9	474102
10	526780

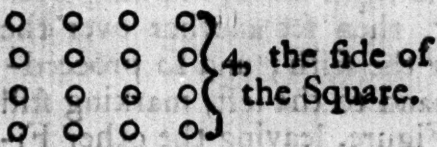
Becauſe the Fraction is three Figures in the Diviſor, therefore I add three Ciphers to the Dividend. As in this laſt Example.

CHAP. V.

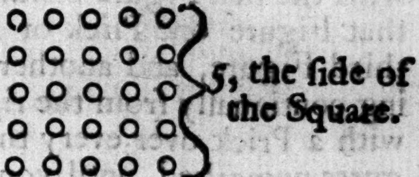
Of the Square Root.

A Square Number is that which is made and produced of two equal Numbers multiplied together, or elſe of one Number multiplied by it ſelf; as 16 is a Square Number, becauſe it is produced of 4 by 4, (which are Numbers equal, or one Number multiplied by it ſelf) likewiſe 25, 36, 49, are three Square Numbers, for they are products of the Multiplication of two equal Numbers, or of one Number multiplied by it ſelf, as 5 by 5, 6 by 6, and 7 by 7. For the Products may be underſtood by their Unites in a Plane, of ſuch kind as ſhall repreſent the form and figure of a Geometrical Plane, as you ſee here under.

The Superfice.



The Superfice.



It is evident by the generation of Squares, that you may make a Square of all Numbers given, and that you may extract the Root of all Squares propoſed; and that likewiſe all Numbers propoſed may be the ſide of ſome Square or another.

There is a Double Root and a Double Square, *viz.* Simple and Compound; The Simple Root is that which hath but one Number, as are 1, 2, 3, 4, 5, 6, 7, 8, and 9; the Squares of which are called Simple Squares. The Compound Root, is that which hath more than one Number, as are 10, 11, 12, 20, 30, *&c.* the Squares of ſuch are called Compound Squares. And before you will extract the Compound Root, you muſt know by heart the nine Simple Roots with their Squares, by means of the following Table.

A Table of the Simple Roots with their Squares.

Simple	Roots.	1.	2	3	4	5	6	7	8	9
	Squares.	1.	4	9	16	25	36	49	64	81

To extract all Roots or Sides of Compound Squares. You muſt well underſtand and imprint in your memories the following Chapter.

CHAP. VI.

Extraction of the Square Root in Decimals.

IN extracting the Root or Side of a Compound Square, you muſt firſt mark the Square Number given, with Points or Pricks from the right hand to the left, beginning with the firſt Figure towards the right hand, marking over that Figure one Prick or Point, then ſet another over the third Figure, and another over the fifth; and ſo proceeding continually from the right hand to the left, marking ſtill with a Prick over every third Figure, leaving the other Figures unmarked, until you come to the laſt Square towards the left hand.

```
 .  .  .
322624(568
25 . . .
————
 726
 106
 636
————
  9024
  1128
  9024
————
  . . . .
```

Firſt find the Simple Root of the Figure or Figures that remain towards the left hand, multiply that Root in it ſelf, ſubtract it out of the Figures towards the left hand: Then draw down the next two Figures to that Remainder, and ſay 2 times 5 the Quotient is 10; ſet 10 under 72, and ſee how often it may be found in 72, ſay 6 times; then ſet 6 under 6, and ſet 6 alſo in the Quotient; then multiply 106 by 6, cometh 636, ſubtract it from 726, there remaineth 90: Then draw down the next two Figures to that Remainder, and ſay, 2 times 56 in the Quotient is 112; ſet 112 under 902, and ſee how often it may be found in 902, ſay 8 times; then ſet 8 under 4, and ſet 8 alſo in the Quotient, then Multiply 1128 by 8 cometh 9024, ſubtract it from 9024 there remaineth nothing; ſo that 568 the Quotient is the juſt Root of the Square Number 322624, &c.

Another

Another Example.

$\dot{7}5\dot{9}3\dot{0}$ (275,553

4 · · ·

359

$4\cancel{7}$

329

3030

$\cancel{5}4\cancel{5}$

2725

30500

$\cancel{5}\cancel{5}\cancel{0}\cancel{5}$

27525

297500

$\cancel{5}\cancel{5}\cancel{1}\cancel{0}\cancel{5}$

275525

2197500

$\cancel{5}\cancel{5}\cancel{1}\cancel{1}\cancel{0}\cancel{3}$

1653309

544191, &c.

CHAP. VII.

Of the Cube Root.

A Cube is a Solid Body, comprehended of ſix equal Square Superficies, and is like unto the Dye of a Table-board.

Definition.

Definition of the Cube Root.

Every Number multiplied in it ſelf maketh a Square Number, of which the Root or Side is the Number multiplied; and every Square multiplied by its Root, maketh a Cube Number, (by the 20th Definition of the 7th Book of *Euclide*:) As 4 times 4 makes 16, (a Square Number, of which the Root is 4) the which 16 being multiplied by the Root 4, the Product giveth 64, a Cube Number, of which the Root is 4.

Likewiſe 5 times 5 maketh 25, a Square Number, which being multiplied by its Root 5, the Product giveth 125, a Cube Number, of which the Root is 5, and ſo of others. And before you can extract the Compound Cube Roots, you muſt firſt know the nine Simple Cube Roots, with their Squares and Cubes. As appeareth in the following Table, which is divided in three Lines, whereof the firſt (which is the uppermoſt) containeth the nine Simple Roots; and the ſecond Line (which is the middle Line) containeth the nine Squares; and the third Line, which is the loweſt, cotaineth the Cube Numbers.

A Table of the Simple Roots, with their Squares and Cubes.

Simples.	Sides.	1	2	3	4	5	6	7	8	9
	Squares.	1	4	9	16	25	36	49	64	81
	Cubes.	1	8	27	64	125	216	343	512	729

CHAP. VIII.

Extraction of the Cube Root in Decimals.

TO prepare a Cube Number for Extraction, put a Point over the firſt place thereof towards the right hand, (to wit, the place of Unites;) then paſſing over the ſecond and third places, put another point over the fourth; and paſſing over the fifth and ſixth, put another over the ſeventh, and in that order, (to wit, two places being intermitted between every two adjacent Points) place as many Points as the Number will permit: So 157464 being given, you are to place the Points as here followeth; and ſo many Points as are in that manner placed, of ſo many Figures the Root demanded will conſiſt.

Having thus prepared your Number, you may ſee it diſtributed by the Points into ſeveral Cubes: So in the ſame Example 157 is the firſt Cube, and 464 the ſecond.

```
  .  .
157464(54
125...
-----
 32464Reſolvend
 75
   15
  765 Diviſor
 -----
  300
   240
     64
 -----
  32464
  .....
```

Firſt, Find the Simple Cube Root by the preceding Table of 157, which is 5; ſubſcribe the Cube of that Root under the firſt Cube of the Number given; ſo 125 being the Cube of 5 the Root, I write it under 157 the firſt Cube of the Number given; and ſubtract this Cube from the firſt Cube of the Number propounded, placing the remainder orderly underneath the Line: So 125 the Cube of 5 being ſubtracted from 157, the remainder is 32: to the ſaid remainder, bring down the next Cube of the Number propounded, (to wit, the Figures or Ciphers which ſtand in the three next places) placing the ſaid Cube next after, to wit, on the right hand of the remainder; ſo the next Cube 464 being placed after the remainder 32, there will be found the Number 32464, which may be called the Reſolvend Having drawn a Line under the Reſolvend, ſquare the Root in the Quotient, that is, multiply it by it ſelf, and ſubſcribe the triple of the ſaid Square or Product, under the Reſolvend, in ſuch manner, that the firſt place (to wit, the place of Unites) of the ſaid triple Square, may ſtand directly under the third place (or place of hundreds) in the Reſolvend: So the Square of the Root 5 is 25, the Triple whereof is 75, which I ſubſcribe under the Reſolvend in ſuch manner, that the Figure 5, which is in the firſt place, (to wit, the place of Unites) in the Triple Product 75, may ſtand under 4, which is ſeated in the third place of the Reſolvend. Triple the Root or Nnmber in the Quotient, and ſubſcribe this Triple Number in ſuch manner that the firſt place thereof, (to wit, the place of Unites) may ſtand directly under the ſecond place (to wit, the place of Tens) in the Reſolvend: So the triple of the Root 5 is 15, which I ſubſcribe in ſuch manner, that the Figure 5, which is in the firſt place (to wit, the place of Unites) in the ſaid triple Number, doth ſtand directly under 6, which is ſeated in the ſecond place of the Reſolvend: The triple Square of the Root, and the triple of the Root being placed one under the other as is directed, draw a Line underneath, and add them together in ſuch order as they are ſeated, and let the Sum be eſteemed as a Diviſor: So the triple Square 75, and the triple Number 15 being added together, as they are ranked in the Work, the Sum will be 765 for a Diviſor: Let the whole Reſolvend, except the firſt place thereof towards the right hand, (to wit, the place of Unites) be eſteemed as a Dividend; then demanding how often the firſt Figure (towards the left hand) of the Diviſor is contained in the correſpondent part of the Dividend, and obſerving in that behalf the Rules before taught in Diviſion, write the Anſwer in the Quotient: So I ask how often 7 (the firſt Figure of the Diviſor towards the left hand) is contained in 32, (the correſpondent part of the Dividend placed above) the Anſwer will be 4, wherefore I write 4 in the Quotient: Having drawn another Line under the Work, multiply the triple Square before ſubſcribed by the Figure laſt placed in the Quotient, and ſubſcribe this Product under the ſaid triple Square, (to wit, Unites under Unites, Tens under Tens, &c.) So 75 being multiplied by 4, the Product is 300, which I ſubſcribe under 75 (the triple Square). Multiply the Figure laſt placed in the Quotient, firſt by it ſelf, and then the Product by the triple Number before ſubſcribed; this done, ſubſcribe the laſt Product under the ſaid triple Number, (to wit, Unites under Unites, Tens under Tens, &c.) So 4 being ſquared or multiplied by it ſelf, the Product is 16, which being multiplied by the triple Number 15, the Pruduct is 240, this therefore I ſubſcribe under the aforeſaid triple Number 15. Subſcribe the Cube of the Figure laſt placed in the Quotient, under the Reſolvend, in ſuch manner that the firſt place of this Cube, (to wit, the place of Unites) may ſtand under the place of Unites in the Reſolvend: So 64 being the Cube of 4, I write it under the Reſolvend 32464, in ſuch manner, that the Figure 4, which is in the place of Unites in the Cube 64, may ſtand under the Figure 4, which is ſeated in the place of Unites of the Reſolvend: Drawing yet another Line under the Work, add the three laſt Numbers together in the ſame order as they are ſeated, and ſubtract the Sum of them from the Reſolvend, placing the Remainder orderly underneath: So the Sum of the three laſt Numbers, as they are ranked in the Work, is 32464, which if you ſubtract out of the Reſolvend 32464, the Remainder is 0. Thus the whole Work being finiſhed, the Cube Root of 157464, (the Number propounded) is found to be 54.

Note 1. When the Sum of the three laſt Numbers before mentioned is greater than the Reſolvend, the Work is erroneous, and then you are to reform it by placing a leſſer Figure in the Quotient.

Note 2. For every one of the particular Cubes (diſtinguiſhed by the Points) except the firſt Cube on the left hand, a Reſolvend is to be ſet apart, by bringing down to the Remainder the next Cube. And as often as a Reſolvend is ſet apart, ſo often is a new Diviſor to be found, by adding the triple of all the Root in the Quotient (conſiſting of what number of places ſoever) to the triple of the Square of ſuch Root, after they are orderly placed, according as is abovementioned.

Note 3. The Work of the Table of Simple Cubes in Folio 9, for finding the firſt Figure of the Root, (as before declared) is but once uſed in the Extraction of the Root of any Number whatſoever; but the Work of all the following Rules, is to be uſed for the finding of every place in the Root except the firſt.

The practice of theſe three Notes will be ſeen, when we deſcribe how to extract the Cube Root of Numbers not Cubical.

CHAP. IX.

Another Example wrought by the Genitures.

SUppoſe a Number given to be 16387064, of which the Cube Root is required: Firſt, You muſt cut the Cube given into Ternaries from the right hand to the leſt, (as was declared in *Chap.* 8.) Then find the Root of the firſt Cube from the leſt hand 16. Whereof the greateſt Root is 2, for 2 being multiplied cubically, giveth 8, the which 8 being deducted from 16, the firſt Cube of the Number propounded, there remaineth 8, then ſet the Root found 2, with the Square thereof above it, and by the ſame the Geniture, and then find a ſecond Figure for the Root of the ſecond Cube, and you ſhall have 5, which ye ſhall ſet down with its Square and Cube under it, right againſt the Geniture towards the right hand; then multiply each one by another, and add the Products together, there cometh 7625, which being ſubtracted from 8387, there doth remain 762; In the ſame manner find a Root for the Numbers remaining to be extracted, and it ſhall be the Root of your third Cube; And the Example will ſtand thus.

$$\begin{array}{rrr|r} 4 & \text{—}300\text{—} & 5 & 6000 \\ 2 & \text{—}30\text{—} & 25 & 1500 \\ & & 125 & 125 \\ \cline{4-4} & & & 7625 \end{array}$$

$$\begin{array}{c|c|c} 8 & \cancel{7}\cancel{6}\cancel{2} & \cancel{0}\cancel{6}\cancel{4} \\ \cancel{1}\cancel{6} & \cancel{3}8\cancel{7} & \\ \hline 2 & 5 & 4 \\ \hline \cancel{7} & \cancel{6}\cancel{2}\cancel{5} & \cancel{0}\cancel{6}\cancel{4} \\ & \cancel{7}\cancel{6}\cancel{2} & \end{array}$$

$$\begin{array}{rrr|r} 625 & \text{—}300\text{—} & 4 & 750000 \\ 25 & \text{—}30\text{—} & 16 & 12000 \\ & & 64 & 64 \\ \cline{4-4} & & & 762064 \end{array}$$

And ſeeing there remaineth nothing, it is manifeſt that the Number propounded 16387064 is a Cube Number, and the Root thereof is 254. By the *4th* Propoſition of the ſecond, and *20th* Definition of the ſeventh Book of *Euclide.*

When we come to calculate the Table of Cubes, by which you may make an Inch Rule for height, or Line of Diameters, the way ſhall be deſcribed how to extract the Cube Root of Numbers not Cubical, or as they are termed Irrational Numbers, from which no true Root can be obtained, yet many times the Error will not be $\frac{1}{100000}$ part of an Unite.

CHAP. X.

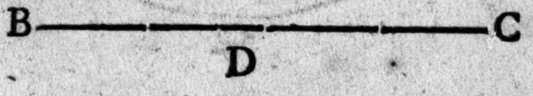
Principles of Geometry.

THere are divers Reaſons which make me to give theſe few Principles of Geometry, becauſe the whole Work of this Book, is either to be done by Arithmetick or Geometry; and beſides that a Gunner cannot obtain to know the truth of a Diameter of a Ball, except he can Geometrically extract the Wind of the Bore of the Peece, and thereby find the Ball fitting ſuch a Peece: And in general will be moſt uſeful for any Gunner.

Definitions.

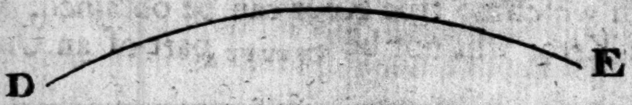
1. A Point or Prick, is that which is the leaſt of all Materials, and it is the beginning of Things, as being void of Length, Breadth, and Depth, having neither Part nor Quantity (expreſſible in Numbers,) and therefore it admits of no Diviſion, but that which is mental only. This Point or Prick is repreſented unto you by the Letter A. Thus A.

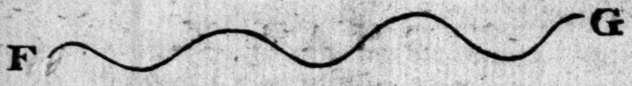
2. A Line is a Magnitude extending it ſelf in length, without breadth or thickneſs, (whether it be a ſtraight line or crooked) and (in reſpect of its length) may be divided into Parts, but will admit of no other Diviſion, but in length only. As is ſet forth to you by the Line BC; the extremities whereof being Points as B and C.



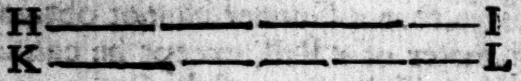
3. A Right or Straight Line, is the neareſt Diſtance that can be betwixt two Points; As is the former Line BC.

4. Circular or Crooked Lines are longer, though they be extended no farther than Right Lines, as are the Lines DE and FG.

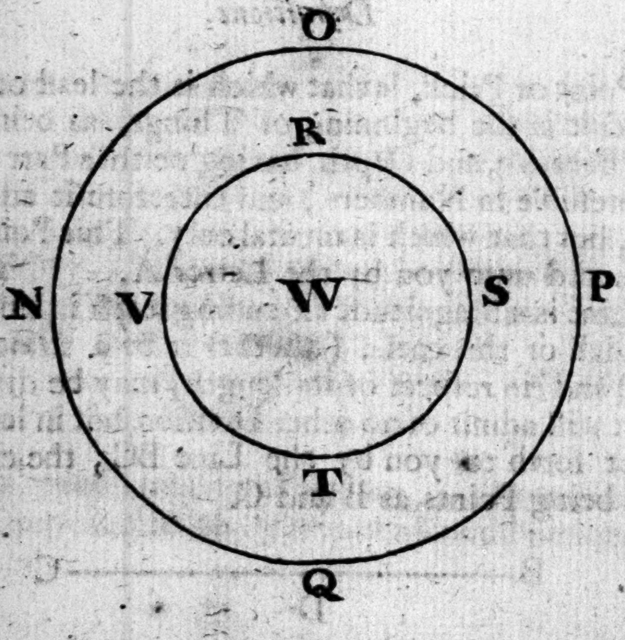




5. Right-lined Parallels, are two ſtraight Lines, ſo drawn, as they are equi-diſtant in all places one from the other; ſo that although they were infinitely extended, yet could they never meet; as may be ſeen by the Lines HI and KL.



6. A Circular Parallel, is a Circle drawn either within or without another Circle, upon one and the ſame Centre, as is.



ſeen by the two Circles, *viz.* NOPQ and RSTV, being both drawn upon the ſame Centre W, and therefore are parallel one to another.

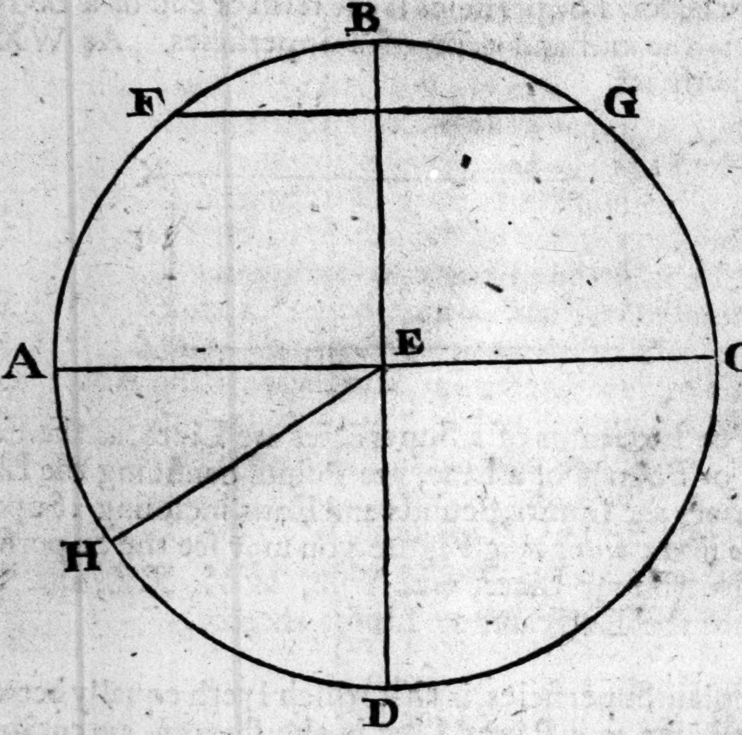
7. A Superfices is the ſecond kind of Quantity, and to it are attributed two Dimenſions, Length and Breadth, but not Thickneſs, for a Superficies is the term or end of a Body, as a Line is the end and term of a Superficies. As WXYZ is a Superficies.

8. The Extreams of a Superficies are Lines, as the Ends, Limits, or Bounds of a Line, are Points confining the Line; ſo are Lines the Limits, Bounds and Ends incloſing a Superficies; As in the foregoing Figure you may ſee the Superficies incloſed with four Lines, *viz.* YW, WX, XZ, and YZ, which are the Extreams or Limits thereof.

9. A plain Superficies, is that which lyeth equally between his Lines, like as a Right Line is the ſhorteſt extention or draught from one Point to another; ſo a plain Superficies is the ſhorteſt extention or draught from one Line to another: As in the preceeding Figure WXYZ.

10. A Figure is that Magnitude comprehended by one Line, or more Lines than one: Under one Line is a Circle; Under more Lines is a Triangle, Quadrangle, Pentagon, Hexagon; and ſo forth.

11. A Circle is that Figure which is comprehended under one Line, called the Circumference, as ABCD; in the middle whereof there is a Point called the Centre, as E; from which, to the Circumference, all Lines being drawn are equal; As in the ſaid Circle the Lines EA, EB, EC and ED are equal.



12. The Diameter of a Circle, is a Right Line drawn through the Centre thereof, and ending at the Circumference on either ſide, dividing the Circle into two equal parts: As the Line AEC in this Circle is the Diameter thereof, becauſe it paſſeth from the Point A to the Point C, and ſo likewiſe through the Centre E, and divideth the whole Circle into two equal parts.

13. The Semi-diameter being the half thereof; as AE and EC, the one Term whereof being the Centre, and the other the Circumference: It followeth by the 11*th* Definition hereof, that all Lines drawn from the Centre to the Circumference are equal; Therefore is BE and ED likewiſe Semi-diameters.

14. A Semi-circle is a Figure which is contained under the Diameter, and under that part of the Circumference which is cut off by the Diameter, as the Semi-circle ABC, is contained under the Diameter AC, and alſo under the part of the Circumference ABC, which is cut off by the Diameter AC.

15. A Quadrant is the fourth part of a Circle, or is contained under two Semi-diameters, and the fourth part of the Circumference, as in the preceding Circle AEB or BEC.

16. A Segment of a Circle, is a part of the Circle, contained under a Chord-Line, (not being the Diameter) and a part of the Circumference, as FBG being the leſſer Segment; and the Remainder to the whole Circle being the greater.

17. A right-lined Angle, is the Inclination, or bowing of one Line to another, which being extended, do concur or meet in a Point, as in the preceding Circle AEB or AEH, *&c.* the middle Letter ſignifying always the Angle, as E.

18. Of Right-lined Angles there be three kinds, *viz.* A Right-Angle, an Obtuſe or Blunt-Angle, and an Acute or Sharp-Angle.

19. A Right-Angle is that, when one Line falling upon another maketh the Angles on both ſides equal, then either of thoſe Angles is a Right-Angle: and the Right Line which ſtandeth erected, is called a Perpendicular-Line to that upon which it ſtandeth. As upon the Right-Line AC, ſuppoſe there do ſtand another Line BE, (as in the preceding Circle) in ſuch ſort, that it maketh the Angles on either ſide thereof equal, namely the Angle AEB on the one ſide, equal to the Angle BEC on the other ſide, then are each of thoſe Angles Right Angles, and the Line BE, which ſtandeth erected on the Line AC, is a Perpendicular to the ſaid Line AC.

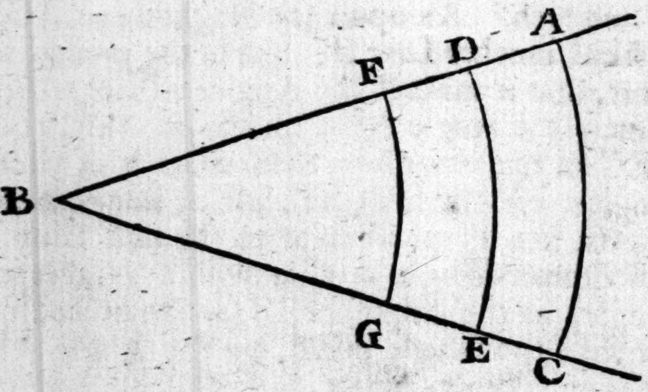
20. An Obtuſe-Angle is that which is greater than a Right-Angle, as the Angle HEB (in the preceding Circle) is greater than the Angle AEB, by the Angle AEH, and therefore is an Obtuſe-Angle.

21. An Acute or Sharp-Angle, is that which is leſs than a Right-Angle, as the Angle AEH is an Acute-Angle, becauſe it is leſs than the Right-Angle AED, by the other Acute-Angle DEH.

Obſ. 1. Here you are to obſerve, That the Circumference of every Circle doth differ from the Circle, as that which is contained, doth differ from that which containeth.

Obſ. 2. The Circumference of every Circle, is underſtood to be divided into 360 Parts, called Degrees; and every one of theſe into 60 other Parts, called Minutes; or into 100 Parts, called Centeſms: But the reaſon of this Diviſion may be demanded, wherefore into 360 and into no other Number, did the firſt Artiſts divide every Circumference? I Anſwer, That only Magnitude being to be divided into certain parts, the ſame ought to be divided into the leaſt and beſt, for dividing as in equal parts: But ſo it was, that no Number under 360 could be had, as being diviſible into more equal parts; and likewiſe being a Number not very troubleſome to Memory. Therefore not without Cauſe or Reaſon they made choice of that Number before any greater or leſſer.

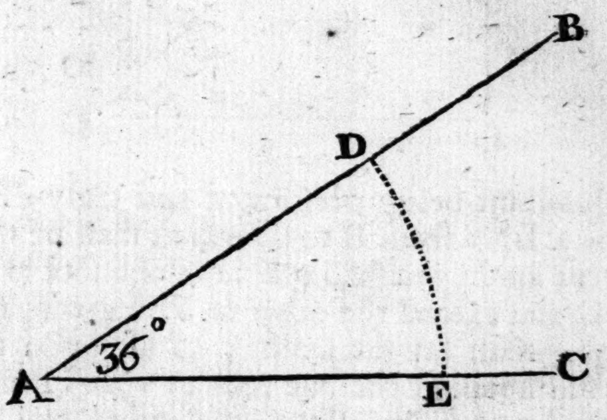
Obſ. 3. From an Arch of the Circumference is taken the Meaſure or Quantity of all Angles; for the Quantity of an Angle, is an Arch or Ark of the Circumference, deſcribed from the Angular Point, and contained betwixt the two Lines forming the Angle. As the Arches FG, DE, AC, deſcribed from the Angular Point B: So that ſo many Degrees as are contained in theſe Arches, ſuch is the quantity of the Angle ABC.



I ſay all theſe Arches being equal; not according to quantity of extenſion: for certain it is that FG will be leſſer than AC;

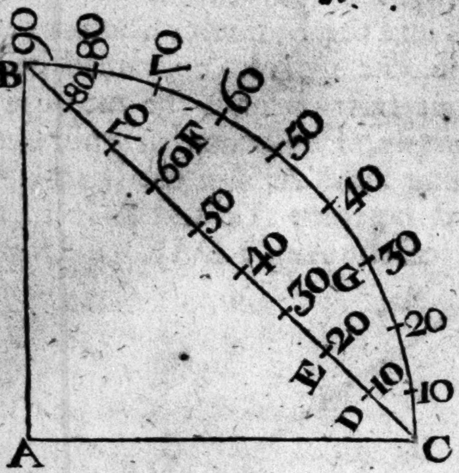
but I ſay that they are equal according to the number of Parts, for there are more Parts in the Arch AC than in FG, although the quantity of the one be greater than the quantity of the other; becauſe all Circles deſcribed from the ſame Centre are equal, all being divided into 360 Degrees.

From hence it follows that every Angle may be meaſured by an Arch of a Circle actually divided; whether it be Semicircle, Quadrant, or Line of Chords, (the conſtruction of which hereafter followeth;) And firſt by a Semi-circle divided into 180 Degrees: Firſt Lay the Centre of the ſame upon the Angular Point, and the Diameter upon one of the Lines forming the Angle, the Degrees contained between theſe two Lines upon your Inſtrument is the meaſure of your Angle. As in this Example, The Centre of your Semi-circle placed upon the Angular Point A, and the Diameter upon AC, the Arch contained between AB and AC, ſuch is DE, which is the meaſure of the Angle DAE 36 Degrees.



22. The meaſure of any Right-lined Angle, may be had by a Line of Chords, which is deſcribed upon a Ruler; which Line is virtually the Arch of a Circle; The Projection whereof is as followeth. Let there be a Quadrant, or fourth part of a Circle, as BAC, divided into 90 Degrees; Firſt, Into three parts, each containing 30 Degrees, by taking the Semi-diameter, as AB, with your Compaſſes; place one foot

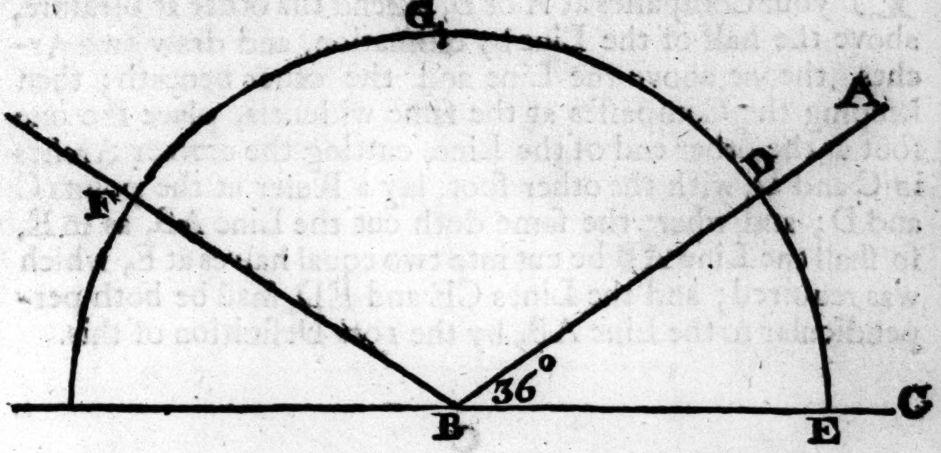
in C, and with the ſame wideneſs ſet the other foot in F; ſet again the one foot of your Compaſſes in B, (the Compaſſes not being altered) and with the other take the extent BG: So your Quadrant ſhall be divided into three equal parts, *viz.* CG 30 degrees, CF 60, and the reſt unto B 90 degrees: Every one of theſe being again ſubdivided into three equal parts; ſo ſhall you have the Quadrant divided into nine parts, or 90 degrees, each part containing ten degrees: and ſo into ſmall parts according to the largeneſs of your Quadrant.



The Quadrant being performed and truly divided: you ſhall draw a Line from B to C, which ſhall be the Chord of 90 degrees; again you ſhall place the one foot of your Compaſſes at C, and extend the other to 10 degrees; the ſame extention you ſhall lay off from C to D, upon the Line of Chords, ſtill keeping the one foot of your Compaſſes at C; again extend your Compaſſes to 20 degrees, and lay them off from C to E; and ſo accordingly to all the reſt, till you have finiſhed the diviſion of your Line. Which being performed, ſhall ſerve you to meaſure the quantity of all Right-lined Angles, as well as by any Circular Arch; being more portable, and more ready for uſe, than any Circular Inſtrument, as Semi-circle, Quadrant, *&c.* as by the following practice is evident.

The Uſe of the Line of Chords.

23. Let there be an Angle, as ABC, whoſe quantity is deſired : The ſame is performed by a Line of Chords; if you place the one foot of your Compaſſes at the end of your Line, and the other upon 60 deg. then the Compaſſes remaining at the ſame wideneſs, place the one foot at B, and draw an Arch as DE; whoſe wideneſs you ſhall take by your Compaſſes, and apply the ſame to your Scale upon the Line of Chords, you ſhall have the Quantity of the Angle 36 degrees.



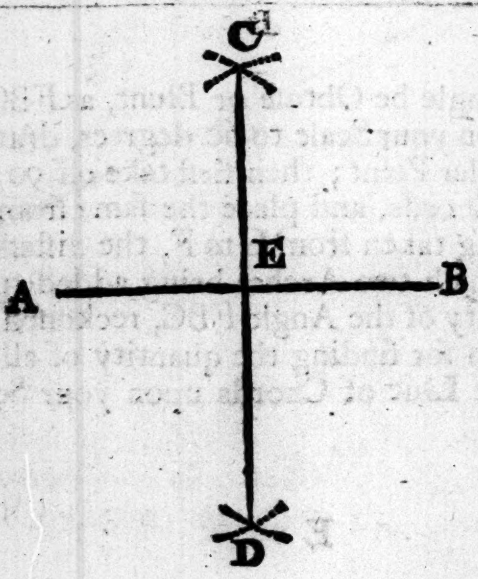
But if the Angle be Obtuſe or Blunt, as FBC, extend the Compaſſes upon your Scale to 60 degrees, drawing an Arch from the Angular Point; then firſt take off 90 degrees from your Line of Chords, and place the ſame from E to G, the remainder being taken from G to F, the diſtance whereof is 54 degrees; which two Arches being added together, ſhall give the quantity of the Angle FBC, reckoned 144 degrees. And thus much for finding the quantity of all Right-lined Angles, by the Line of Chords upon your Scale.

CHAP. XI.

Geometrical Problems.

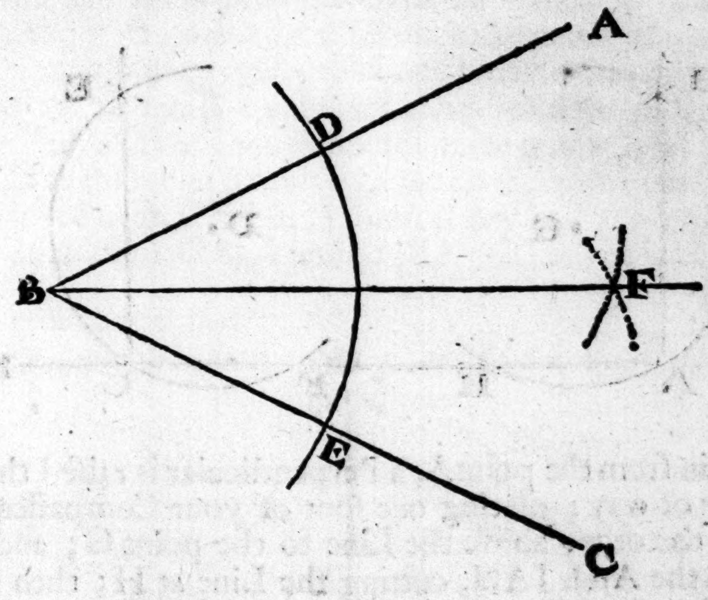
To divide a Line given into two equal Parts, at Right-Angles.

Prob. 1. LET the Line given be AB; having placed the one foot of your Compaſſes at A or B, extend the other at pleaſure, above the half of the Line by eſtimation, and draw two Arches, theone above the Line and the other beneath; then keeping the Compaſſes at the ſame wideneſs, place the one foot at the other end of the Line, cutting the former Arches in C and D, with the other foot, lay a Ruler at the points C and D; and where the ſame doth cut the Line AB, as in E, ſo ſhall the Line AB be cut into two equal halves at E, which was required; and the Lines CE and ED, ſhall be both perpendicular to the Line AB, by the 19*th* Definition of this.



An Angle being given, to divide the ſame into two halves.

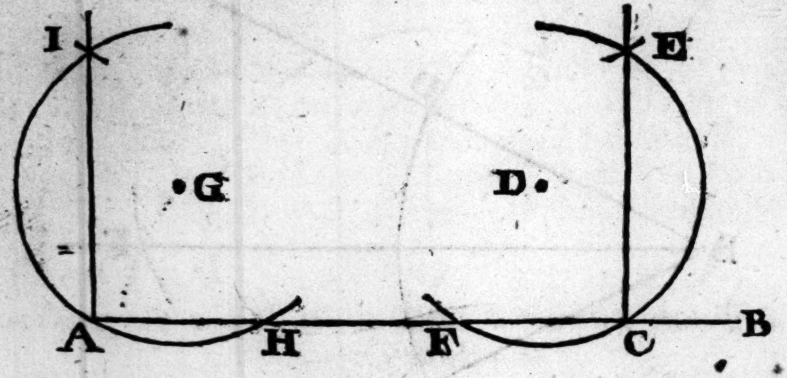
Let the Angle be ABC, to be divided into two equal halves: Place the one foot of your Compaſſes at B, and extend the other at your pleaſure to D and E; deſcribe two Arches cutting each other in the point F: So ſhall you divide the Angle ABC into two equal halves, if you draw a Line from B to F, with two Angles ABF, and FBC, as equal to the whole Angle ABC, being divided into two halves. *Prob. 2.*



From any Point, or from the end of a Line, to erect or raiſe a Perpendicular.

Prob. 3. Let there be given the Line AB, and the Point in the ſame given C, from which a Perpendicular is to be raiſed.

Place the one foot of your Compaſſes at C, and with the other take at pleaſure above the Line, as D; then from the point D, deſcribe the Arch of a Circle, as ECF, cutting the Line AB in F; then lay your Ruler at F and D, and where it cutteth the Arch as in E, draw a Line from C to E, which ſhall be perpendicular to AB, from the point C.

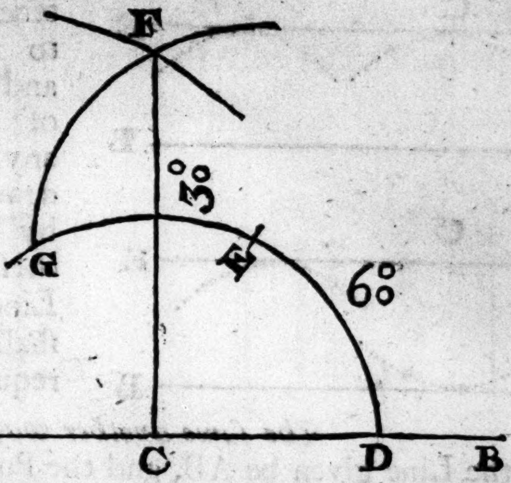


Again from the point A, a Perpendicular is raiſed the ſame manner of way; placeing one foot of your Compaſſes at A, extend the other above the Line to the point G; and draw from G the Arch IAH, cutting the Line at H; then laying your Ruler by G and H, and where it cutteth the Arch as in I, from A to I draw a Line, ſo ſhall AI be a perpendicular from the end of the Line AB, or from the point A.

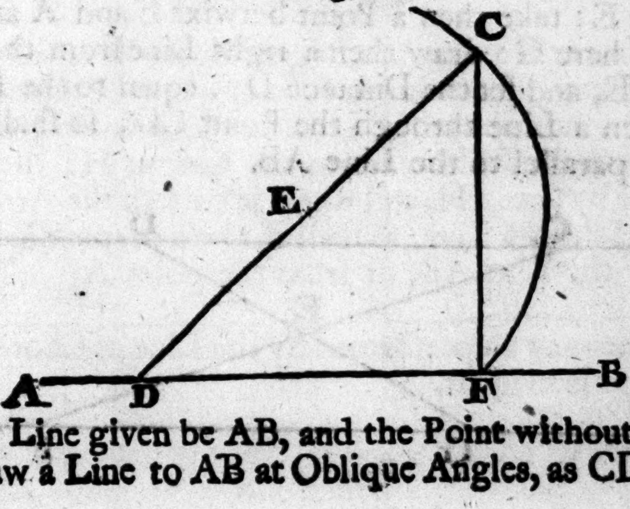
The ſame may be performed by the Line of Chords, as by the practice is evident.

The ſame another way.

A Perpendicular may be raiſed after this manner; As let the Line be AB; and a Point in the ſame Line given, let be C: place the one foot of the Compaſſes at C, and with the other draw an Arch above a Quadrant, as GED; then place the diſtance of CD from D to E; then placing the one foot at E, draw the Arch GF: then removing your Compaſſes, place the one foot at G, and with the other cut the Arch in F: Laſtly, From F to C, draw a Line FC; ſo ſhall FC be a Perpendicular from the point C.



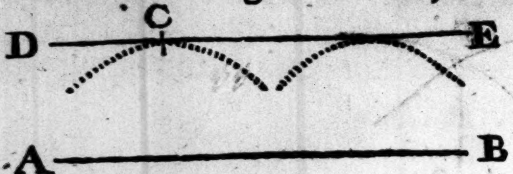
From a Point without a Line, to let fall a Perpendicular to a Line given.

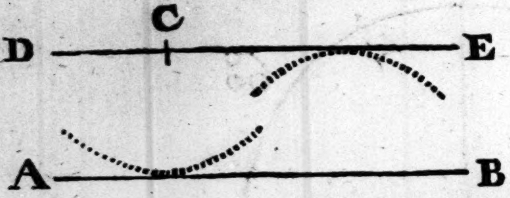


Let the Line given be AB, and the Point without the ſame *Prob.* 4. at C: Draw a Line to AB at Oblique Angles, as CD; which you ſhall cut (by the firſt Problem) in two halves at E; then place the one foot of your Compaſſes at E, extend the other unto C, drawing the Arch CF: and where the ſame cutteth the Line AB, as in F, from C to F draw a Line, as CF; ſo ſhall CF be a Perpendicular let fall from the Point C, upon the Line AB, as was required.

A Line being given, to draw a Parallel to the ſame, at any Diſtance required.

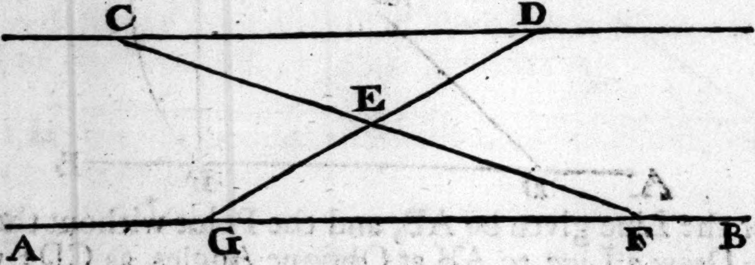
Prob. 5. Let the Line given be AB, and the Diſtance from C: Extend your Compaſſes to the length of C, and placing one foot of your Compaſſes in any Point of the Line, draw two Arches; and by the Compaſs of theſe Arches, draw a Line as DE; which ſhall be parallel to AB required; as CE.





The ſame another way.

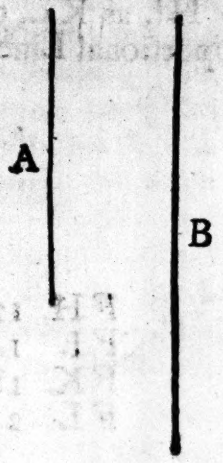
Let the Line given be AB, and the Point at C: From the Point C, draw a Line at pleaſure unto AB, which ſhall touch in F, which you ſhall cut (by the firſt Problem) into two halves at E: take then a Point betwixt F and A at pleaſure, which is here G: draw then a right Line from the Point G, through E, and ſet the Diſtance DE, equal to the Line EG: draw then a Line through the Point CD; ſo ſhall the ſame Line be parallel to the Line AB.



Two Lines being given, to find a third proportional Line.

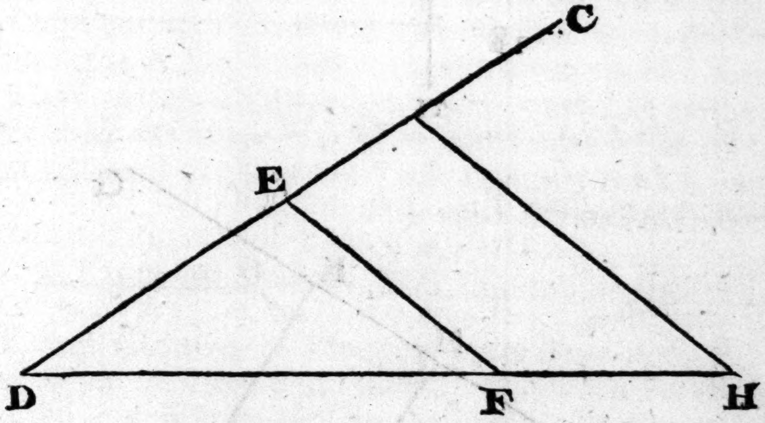
Let A and B be two Lines given, and let it be required to find a third Line in proportion to them. *Prob. 6.*

Firſt, Make any Angle as CDH; then ſet the Line A from D to E, and the Line B from D to F, and alſo from D to G; then draw EF: that done, by the Point G draw a parallel to EF, as GH: So ſhall DH, be the third proportional Line required.



A . 4.
B . 6.

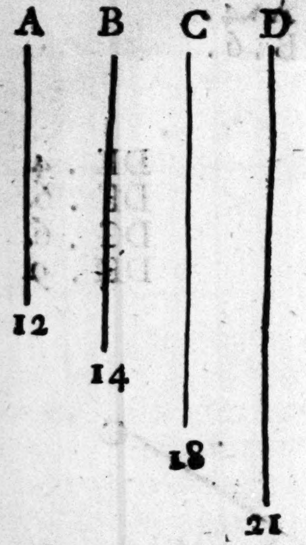
DE . 4.
DF . 6.
DG . 6.
DH . 9.



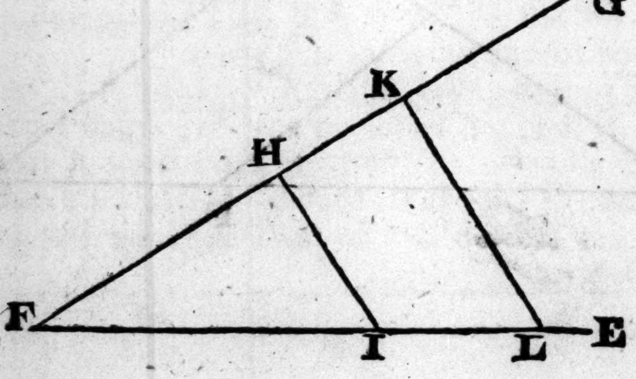
Three Lines being given, to find a fourth in proportion, that is to perform the Rule of Three in Lines.

Prob. 7. Let A B and C be three Lines given, and it is required to find a fourth proportional Line.

Firſt (as in the laſt Problem) make any Angle at Pleaſure, as the Angle EFG; Then take with your Compaſſes the Line A, and ſet it from F to H; take alſo the Line B, and ſet it from F to I, and draw the Line HI: That done, take the third Line C, and ſet it upon the Line FG, *viz.* (always upon the ſame Line where the firſt Line A was placed) from F to K; then by K draw a Parallel to HI, as KL, to cut FE in L: So ſhall FL be the fourth Proportional Line required.



FH. 12.
FI. 14.
FK. 18.
FL. 21.

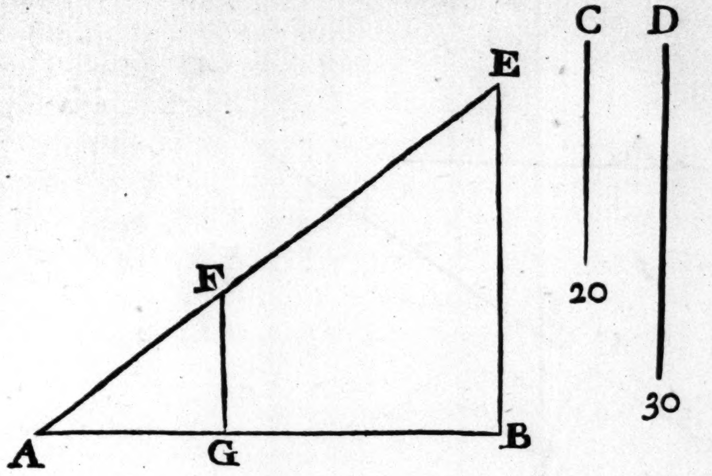


To

To divide a Line given into two Parts, in proportion one to the other, according to two Lines given.

Let A B be a Line given, to be divided into two ſuch Parts that the leſſer may be in proportion to the greater: As the Line C, to the Line D. *Prob.* 8

From the End A draw the Line A E, making the Angle B A E; then ſet the Line C from A to F, and the Line D from F to E, and draw the Line E B: Laſtly, By the Point F draw a Parallel to E B, as F G, to cut A B in G: So ſhall A B be divided in G, as C to D, which was required.



A F. 20.
F F. 30.
A G. 16.
G B. 24.

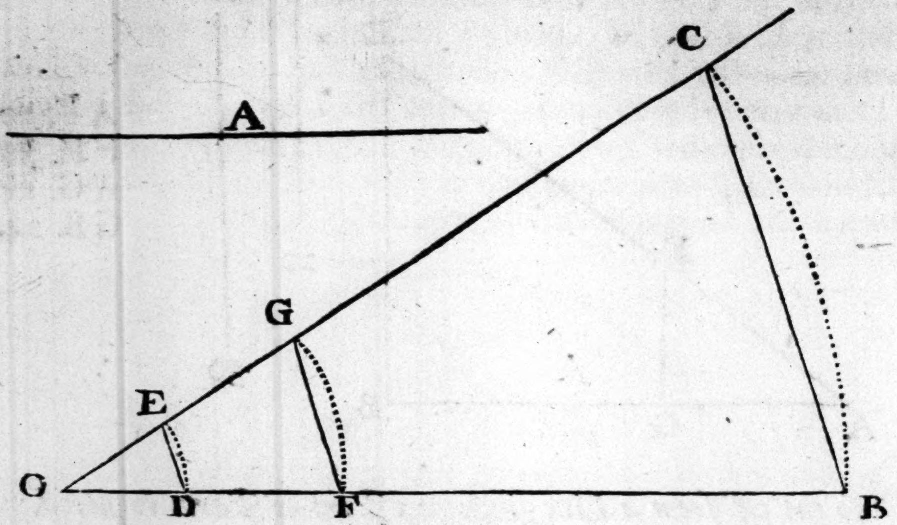
To cut off from a Line given any Part or Parts required.

Let in the laſt Diagram A B be a Line given, and let it be required to cut off from it $\frac{2}{5}$ parts. *Prob.* 9.

Firſt, From the End A, draw the Line A E, making any Angle as B A E; then ſet on any five equal parts from A to E, and alſo two of the ſame parts from A to F: That done, draw the Line E B; then by F draw a Parallel thereunto, to cut A B in G: So ſhall A G be the $\frac{2}{5}$ parts of A B, which was required.

To divide a Line in ſuch Sort, as another Line is before divided.

Prob. 10 This Problem differeth not much from the two laſt Problems. Draw a Right Line at pleaſure, as the Line O B, which Line you ſhall divide into 100 equal Parts as exactly as you can; then extend your Compaſſes to the Diſtance OB, and deſcribe an Arch; in which Arch you are to include the deſired Line A; then draw the Line OC, and you have the Angle C O B: Which we ſhall hold for a Ground-Rule; becauſe the Legs O B and OC contain each of them 100 or 1000 Parts, which is in the Line A.



For Example.

I would have 35 parts of the Line A, (whoſe whole length making 100 parts, as the Line O B doth): I number on the Line O B 35 parts from O to F; with this diſtance I draw the Arch F G; then is the neareſt Diſtance from F to G a Right Line, which is the 35 parts of the Line A.

Likewiſe if it were deſired to have 15 parts of the Line A: Then draw from O the Arch E D; which Diſtance is the deſired 15 parts of the Line A; as the Learned *Adriani Meti* doth teach. And alſo how to find the Parts of a longer

Line, than the Line of Meaſure itſelf is; it is done after the ſame Manner; and is of great Uſe to a Gunner.

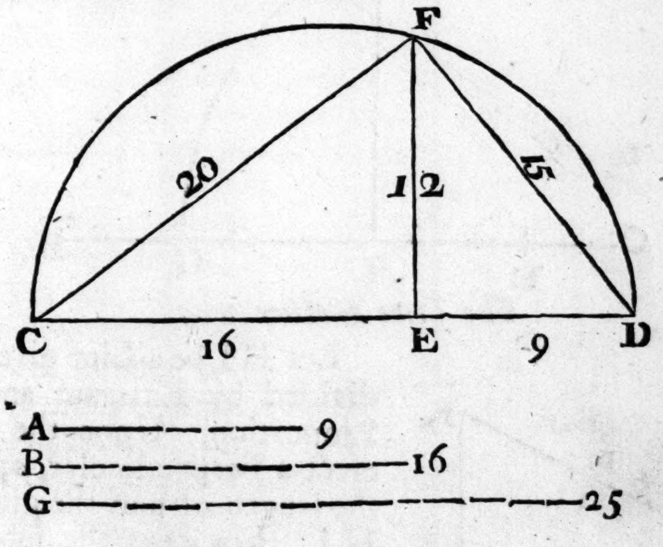
Uſe.

This may be of great Uſe, if the Gunner be to find the firſt Pound Ball in a ſtrange Place, and the Weight unequal to Ours.

Between two Lines given, to find a mean Proportion.

Let A and B be two Lines given, between the which it *Prob.* 11 is required to find a mean Proportion.

Join the Lines A and B ſo together, that they make one Right Line as C D, being joined together in the Point E: and upon the Line CD deſcribe the Semi-circle, *viz.* CFD: Then upon the Point E, where the Lines A and B being joined together meet, erect a Perpendicular to cut the Limb in F, as E F, which ſhall be a mean Proportion between the Lines A and B required.



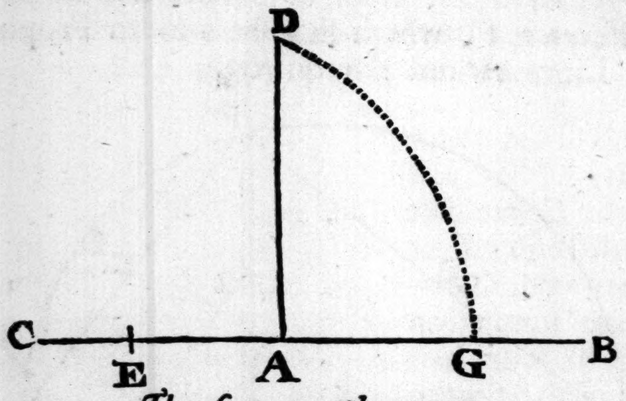
The ſame another Way.

Again in the ſame Diagram, let the Lines A and G be given, between the which it is required to a find a mean Proportion.

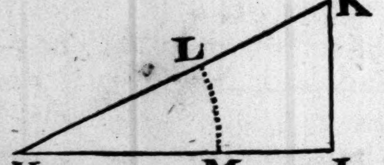
Take the Line G, and lay it down from C to D, and draw C D; whereupon deſcribe the Semi-circle C F D: Then take the Line A, and ſet it from D to E; Then upon the Point E, erect a Perpendicular to cut the Limb in F: Laſtly, Draw D F, which ſhall be a mean Proportion between D E and D C, or between the Lines A and G required. And if you draw C F, it ſhall be a mean between B and G, that is, between C E and C D.

To divide a Line given by Extream and Mean Proportion.

Prob. 12. Let A B be a Line given to be divided by Extream and Mean Proportion. Increaſe A B at length to C; then upon the Point A erect a Perpendicular as A D, of the length of A B: That done, take half A D, or A B, and ſet it from A to E, then with the diſtance E D make the Arch D G: So ſhall A B be divided by Extream and Mean Proportion in G, and A G is the greater Segment, and G B the leſſer.



The ſame another way.

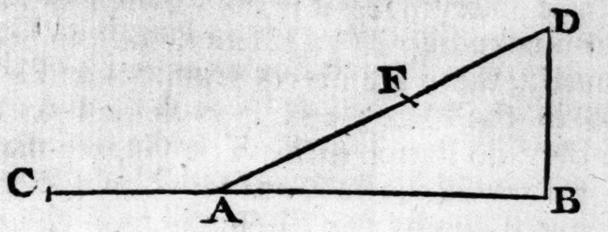


Let H I be a Line given, to be divided by Extream and Mean Proportion. Upon the End I, erect a Perpendicular, as I K, of the length of half the given Line H I; then draw the ſubtendant ſide H K: That done, ſet K I from K to L; again, ſet H L from H to M; ſo ſhall H I be divided by Extream and Mean Proportion in M: And H M ſhall be the greater Segment, and M I the leſſer.

The

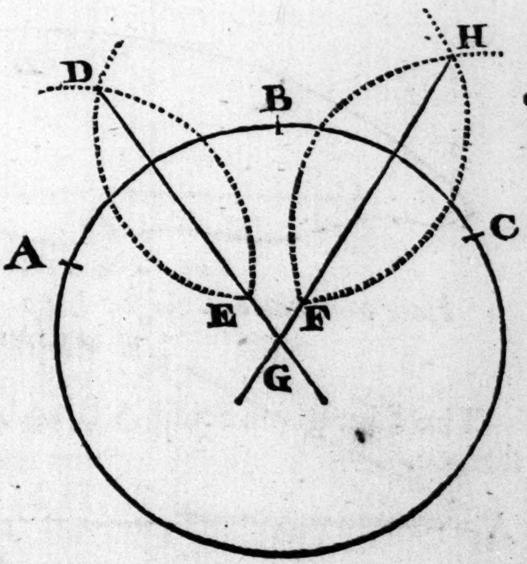
The greater Segment of a Line divided by Extream and Mean Proportion, to find the whole Line.

*Prob.*13. Let A B be the greater Segment given, and the whole Line is required. Increaſe B A to C; then upon the end B erect a Perpendicular of half the length of A B, as B D; and draw the ſubtendant ſide A D; from which ſubtract D B, reſts A F: That done, ſet A F from A to C; ſo ſhall C B be the whole Line required.



To deſcribe a Circle upon any three Points given, not being in a Right Line.

*Prob.*14. Let A B C be three Points given. Set one Foot of the Compaſſes in the middle Point at B, and open your Compaſſes to any Extention that is above one half of the diſtance between B, and the fartheſt of the other two Points, and with that diſtance draw the blind Arches D E and F H: with the ſame extent ſet one Foot in C, draw the Arch F H: Again with the ſame extent, ſetting one Foot in the Point A, draw the Arch D E: then laying a Ruler to the Interſection of theſe Arches, draw the Lines D G and H G; which

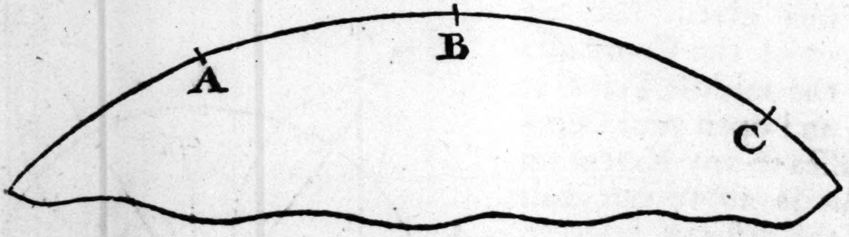


which will croſs each other in the Point G: and there is the Centre of the Circle inquired. Where ſetting one Foot of your Compaſſes, and extending the other to any of the three Points, you deſcribe the Arch of a Circle, which ſhall paſs through the three Points given, and give the whole Circumference required; which having, you may find the Diameter by the 12*th* Definition of Chap. 10. of this Book.

Obſervation.

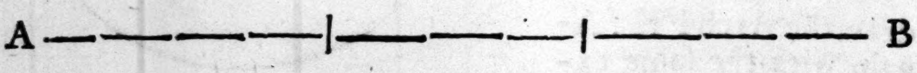
By a Segment, or a piece of a Ball being found, to know the weight of the whole Ball.

Here is to be obſerved, That if any Town, Fort, or Place, be beſieged or blocked up by an Enemy, and the Enemy ſhooting continually, there are divers Segments or Pieces of their Ball found in the Place; and it is deſired to know what Ordnance they do Batter with. The Gunner ſhall take the Segment or Piece of the Ball, and lay it on a Piece of Paper, and ſet there down by the Circumference three Pricks or Points, as A B C in the Figure following, and thereby, and by the preceding Problem, ſhall find the Diameter, Centre, and Circumference of the Ball, whereby you may know the Weight of that Ball, as is deſcribed in *page* 54.

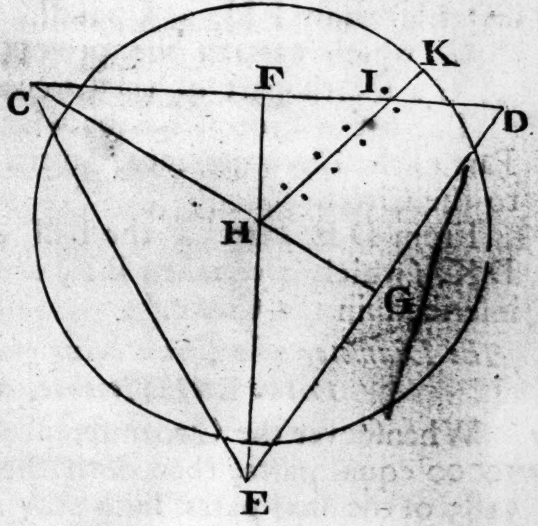


How to reduce a Right Line into the Circumference of a Circle.

Prob. 15 The Line given being A B, to be reduced into a Circumference.



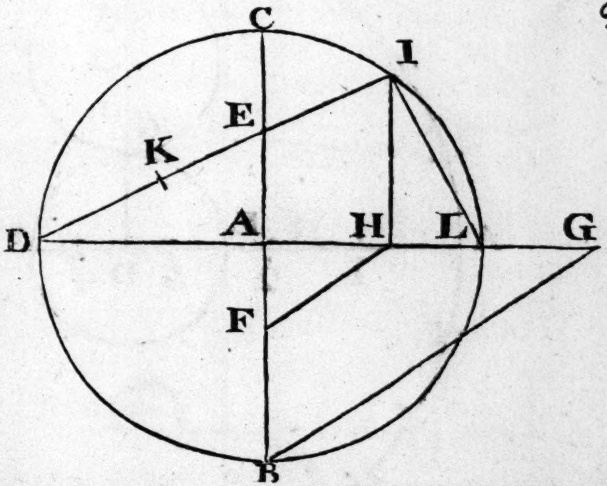
The which Line AB, you ſhall firſt divide into three equal Parts, and of theſe three Parts you ſhall make an equilateral Triangle,



Triangle, as CDE; the half of CD is F, and the half of the ſide DE is G; and where they cut one another, as in H, that is the Centre of the Triangle CDE: Further, divide DF into Halves with the Point I; draw then a Right Line from the Centre H, to I, which is HK; and divide the Line HI into four equal Parts, of which you ſhall add one Part unto HI, which ſhall be HK, (which is the ſame fourth Part five times ſet); ſet then one Foot of your Compaſſes in the Point H, and the other in the Point K; and draw with the ſame Diſtance a round Circle, whoſe Circumference ſhall be equal to the Line given, *viz.* the Line AB, which was required.

How to reduce the Circle of a Circumference given, into a Right Line.

Prob. 16.



Let the Circle given be ABCD. Divide the ſame Circle in 4 equal Parts with the two Diameters BC, and DL, which cut teth one another at Right Angles in A; divide AC in the middle in E, through the which draw DI, and from I draw a Perpendicular upon DL, and divide AB in Extream and Mean Proportion at F, (by Problem 12 of this) draw FH, and parallel to the ſame from B draw BG, which cutteth the prolonged Line DL in G; ſo is AG a fourth part of the Circumference BDCL.

The Mean Proportion betwixt DL and AG, the fourth Part of the Circumference, giveth the ſide of a Square equal to the Circle.

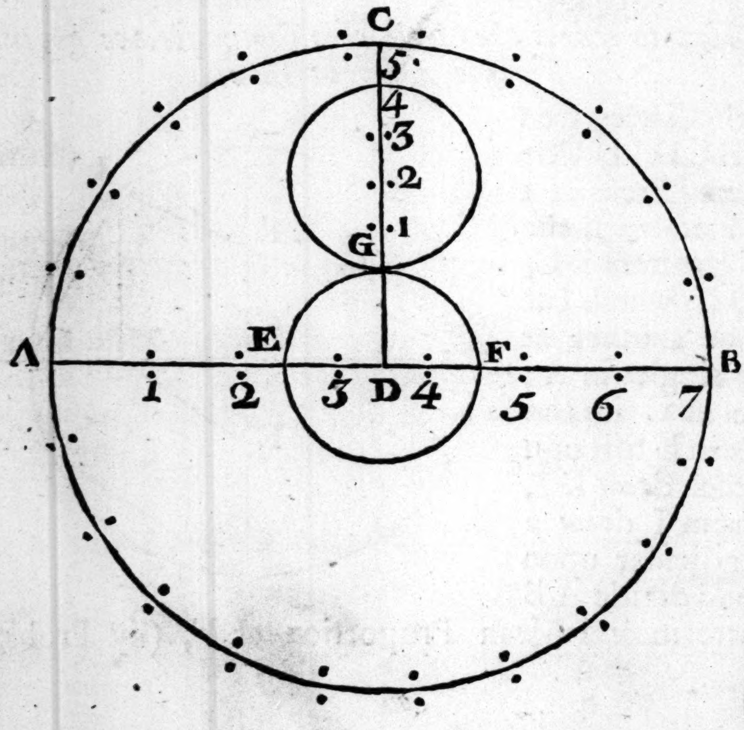
From DE ſubtract the half of AC, there remaineth DK, (which is equal to BF) and is the ſide of a Decagon inſcribed in the Circle.

The Diameter of a Circle being given, to find its Proportion to the Circumference, or the Reverſe.

Prob. 17

The true knowledge of this Problem is of great Uſe for Gunners, both by Sea and Land.

Whenſoever the Circumference of a Circle is divided into 10000 equal parts, then doth the Diameter thereof contain 3183 of the ſaid parts, ſaith *Adriani Meti*. But *Archimedes* ſheweth us the eaſieſt and fitteſt for our purpoſe; to wit, That if the Circumference be divided into 22 equal parts; then the Diameter doth contain ſeven of the like parts; as is demonſtrated in this Figure, where you may ſee, that in the Circle ABC, the Circumference is divided into 22 equal parts, and the Diameter AB doth contain ſeven of the ſame parts.



A Light to the Art of Gunnery.

CHAP. XII.

How to know the Proportion of a true Fortified Iron-Gun.

IN the laſt Problem, you have the Proportion of a true Fortified Iron Peece; for a true Fortified Peece of of Ordnance being of Iron, hath 11 Diameters of the Bore about the Breech, meaſuring at the Touch-hole betwixt the Rings AB, which to deſcribe is thus;

In the Diagram of the 17*th* Problem, the Diameter being divided into 7 equal parts, take with your Compaſſes one of the parts, and ſet one foot in the Centre D, and with the other draw the Circle EGF, then ſhall the Line EF be the Diameter of the Bore of that Peece of Ordnance, and the Circle ACB, the Circumference of the Breech of the ſame Peece at the Touch-hole: Whence it followeth that one 22 parts of a well proportioned Peece of Ordnance made of Iron, meaſured about the Breech, is half the Diameter of the Bore of the ſame Peece. And therefore the thickneſs of the Metal at the Touch-hole is 1 $\frac{1}{4}$ Inches, as appeareth from G to C. A true Fortified Peece of Iron Ordnance hath 11 Diameters of her Bore about the Breech, 9 Diameters at the Trunions, and 7 Diameters at the Neck, near the Muſle.

Suppoſe a true Fortified Peece of Ordnance of Iron be 8 Inches Diameter in her Bore, I demand the thickneſs of Metal at the Touch-hole, at the Trunions, and at the Neck.

Example 1.

Say, 11 times 8 Inches is 88 Inches.

Then, as 22——7——88

7

22)616(28 Inches Diameter at the Touch-hole.

176

. . .

Inches.

From 28 Subtract the Diameter of the Bore, half the Remainder is the thickneſs of Metal at the Touch-hole.

28

8

$\frac{1}{2}$)20(10 Inches or $1\frac{1}{4}$ of the Diameter.

Example 2.

Say, 9 times 8 is 72

Then, as 22——7——72

7

22)504(22,9 Inches Diameter at the Trunions.

64

200

. . 2

Inches.

22,9

8

$\frac{1}{2}$)14,9(7,$\frac{45}{100}$

The thickneſs of Metal at the Trunions is $7\frac{3}{8}$ Inches.

Example 3.

Say, 7 times 8 is 56.

Then as 22——7——56

7

22)394(17,9 Inches Diameter at the Neck.

174

200

. . . 2

17,9

8

. 9 . $\frac{9}{10}$

$4\frac{7}{8}$ Inches, the thickneſs of Metal at the Neck.

For the Length of the Peece, if you take 7 Diameters at the Touch-hole, and place 3 of them between the Breech and the Trunions, and 4 between the Trunions and the Muſle, then ſhe is a true Fortified and Proportioned Peece of Ordnance, whether it be of Iron or Braſs. A Braſs Peece of Ordnance hath 9 Diameters of her Bore about the Breech at the Touch-hole, 7 at the Trunions, and 5 at the Muſle, and the length in proportion to the Iron Peece of Ordnance.

Example.

Admit a Braſs Peece of Ordnance be 7 Inches Diameter in her Bore, I demand the thickneſs at the Touch-hole, the Trunions, and the Muſle.

Example 1.

Say, 9 time 7 is 63.
Then, as 22——7——63
7
22)441·(20 Inches, the Diameter at the Touch-hole.
·· ·1

Inches.
20
7
$\frac{1}{2}$)13(6$\frac{5}{10}$ Inches, the thickneſs of the Metal at the Touch-Hole.
1

Example 2.

Say, 7 times 7 is 49.
Then as, 22——7——49
7
22)343(16,5 Inches, the Diameter at the Trunions.
143·
110
···

16$\frac{5}{10}$
7
$\frac{1}{2}$)9,5(4$\frac{7}{10}$.

The thickneſs of Metal at the Trunions is 4 $\frac{7}{10}$ Inches.

***Example* 3.**

Say, 9 times 5 is 45.
Then, as 22 —— 7 —— 45
7 Inches.
22) 315. ($14\frac{3}{10}$ Inches, Diameter at the Neck.
95
70
4

Inches.
$14\frac{3}{10}$
7
$\frac{1}{2}$) 7 ($3\frac{6}{10}$
1,3

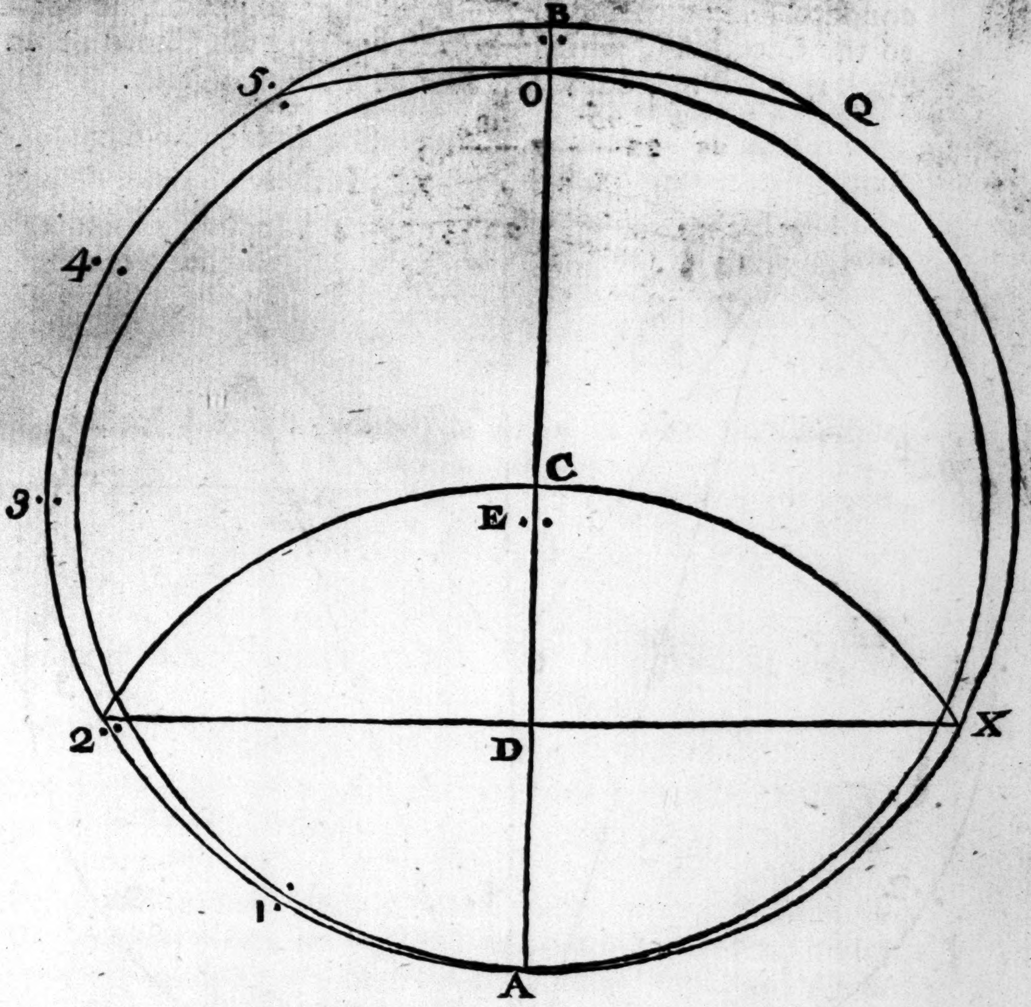
The thickneſs of Metal at the Neck is $3\frac{6}{10}$ Inches.

CHAP. XIII.

How to Extract the Wind from the Bore of a Peece Geometrically, and thereby to know a fit Ball for the ſame.

FIrſt draw the Diameter BA, which divided in two equal Parts at C, extend your Compaſſes from C to A, and draw the Circle 1. 2. 3. 4. 5, which here repreſents the Bore of the Peece, then keeping your Compaſſes at the ſame Extention, place one Foot in A, and draw the Arch 2CQ, the Chord-Line 2X divides the Semidiameter of the Bore into two equal parts, then take the diſtance AD or DC, in your Compaſſes, ſetting one foot in A, and ſet it from A to 1. 2. 3. 4. 5; then extend your Compaſſes from A to 5, and draw the Arch 5.O.Q. whereof A is the Centre, then divide the diſtance OB into two equal parts, and take one of thoſe parts, and ſet upon the Diameter below C in the point E, then extend your Compaſſes from E to A, keeping one foot in E, draw the Circle, whoſe Diameter is AEO: and is a Ball fit for ſuch a Peece as hath for its Diameter ACB.

The

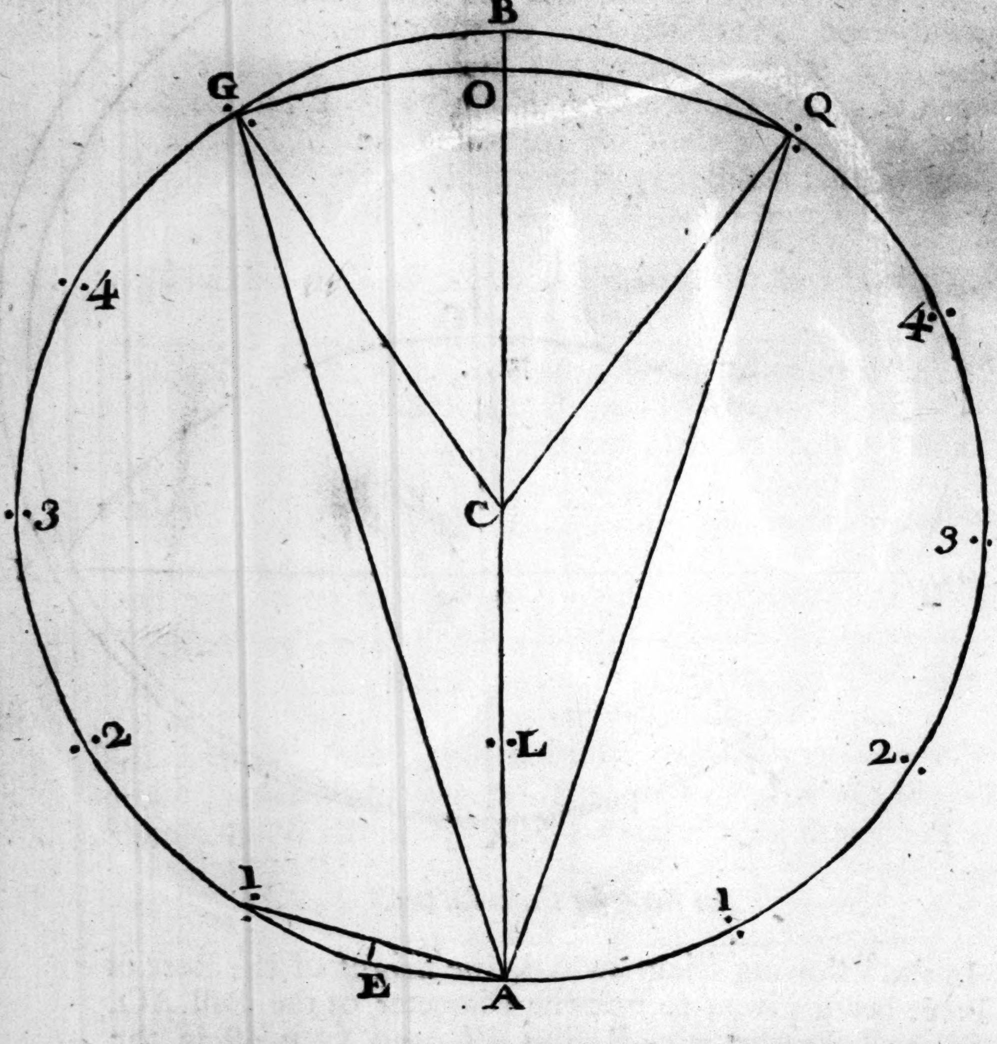


The ſame by Calculation.

In the following Diagram AB, the height of the Bore of a Peece being given, to find the Diameter of the Ball AO.

Firſt, Take the Semi-Radius AL, and ſet it off in the Circumference from A towards B five times, as you ſee here marked with 1. 2 3. 4. G: or 1. 2. 3. 4. Q; then extend your Compaſſes from A to G, and draw the Arch GOQ, ſo is AO the Diameter of the Ball, and BO the Wind.

Firſt, Conſider that AG or AQ is equal to AO, and A1 equal to AL, then AL being Semi-Radius 50000, is equal to the Chord A1, withal Conſidering that the Chord of an Arch is equal to double the Sine of half that Arch.



Now then 25000 the half of AL is the Sine AE, which in the Table of Natural Sines, giveth 14° 29′, the double of which giveth 28° 58′ for the quantity of the Arch A1; which being quintupled or multiplied by 5, giveth 144° 50′ for the Arch AG, or AQ; ſo that the Arch GBQ is 70° 20′; the Chord AG is equal to twice the Sine of 72° 25′, 25′, *viz.* 95327; the double thereof is 190654, which is to the height of the Ball, in Compariſon to the Bore AB, 200000, twice the Radius or Diameter.

In Proportion, as double is to double, ſo is ſingle to ſingle; therefore as 190654 is unto the Diameter 200000, ſo is the half thereof 95327, the Sine of 72° 25′ unto the Radius: I ſay then, if the height of the Bore of any Peece of Ordnance be divided into 100000 Parts, the Ball for the ſame Peece is 95327 of the ſame parts, and the Difference 4673 parts, ſo that the Bore will be 21 $\frac{2}{5}$ times the height of the Wind.

If the Height of the Bore be given, to find the Diameter of the Ball.

1. The Proportion is: As the Radius is to the Height of the Bore given: So is the Sine of 72° 25′ unto the Diameter of the Ball required.

Or, if the Diameter of the Ball be given; to find the Bore: Say then,

2. As the Sine of 72° 25′, is in Proportion to the Diameter of the Ball: So is the Radius to the Height of the Bore.

Example 1.

I have an Iron Ball whoſe Diameter is 4 Inches, and Weighs 9℔ English weight, I deſire to know what Height the Bore muſt be, which this Ball will fit, the Wind allowed for.

Sine In. Rad.
As 95327 ——— 4 ——— 10.000
100000
95327) 400000) 4,19 Inches, the Height of the Bore required.
381308
186920
95327
915930
857943
57987

I Anſwer, The Height of the Bore of ſuch a Peece of Ordnance, is 4 Inches and $\frac{1}{5}$ part, fere.

Example 2.

I have a Gun whoſe Bore is 6 Inches Diameter, and I would know what the Diameter of the Ball muſt be that will fit ſuch a Peece, the Wind allowed for.

Rad. In.
As 10.0000 ——— 6 ——— 95327
95327
571962

I Anſwer, The Diameter of the Ball that will fit ſuch a Peece, muſt be 5 Inches and $\frac{7}{10}$ Parts of an Inch.

Another way.

If the Diameter of the Ball be given, to find the Height of the Bore.

Say, as 19 is to 20, ſo is 4 Inches the Diameter of the Ball, to the Height of the Bore.

But if the Height of the Bore be given, to find the the Diameter of the Ball.

Say, as 20 is to 19, ſo is the Height of the Bore, to the Diameter of the Ball.

Example 1.

A Ball that is 4 Inches Diameter, I demand the Height of the Bore.

In.
As 19 ——— 20 ——— 4
4
19) 80 (4,$\frac{2}{10}$ Inches
76
·40
38
·2

I Anſwer, the Height of the Bore muſt be 4 Inches and 2 tenths of an Inch, or $\frac{1}{5}$ part of an Inch.

Example 2.

The Bore of a Peece is 6 Inches Diameter, the Diameter of the Ball is required.

```
                                   In.
Say, as 20 ———————— 19 ———— ———— 6
                     6
                 ————————
              20 )114( 5 7/10
                 )100(
                 ————————
                   140
                   140
                  ————
                   100
```

I Anſwer, the Diameter of the Ball muſt be 5 Inches, and and 7 tenths of an Inch.

CHAP. XIV.

TO prove all ſorts of Guns; your Braſs Guns muſt have one Diameter of the Bore for the thickneſs of Metal at the Vent, and the Iron Guns muſt have 11 Diameters for her Circumference, (that is to ſay) one Diameter and $\frac{1}{4}$ at the Vent. All Guns thus Fortified will bear their Powder, but if not, you muſt obſerve theſe Rules following.

From the Falconet to the Minion the Proportion holds, as 5 to 4, ſo is the Weight of the Shot for Proof to the Powder due for Service. From the Saker to the Demiculver, the Proportion is as 4 to 3, ſo is the Weight of the Shot for Proof to the Powder due for Service. For the whole Culverin it holds, as 3 to 2, ſo is the Weight of the Shot for Proof, to the Powder due for Service, and 12 Pounder. Now all theſe ſorts of Guns muſt have the Weight of their Shot for Proof, but if Drakes $\frac{2}{3}$ of the Powder for Service. For 24 Pounder, the Demicanon and whole Cannon, ſay, as 6 to 4, ſo is the Weight of the Shot to the Powder for Proof; and as 4 to 3, ſo is the Weight of the Powder for Proof to the Weight for Service; but for Drakes the $\frac{2}{3}$.

Prob. 1. A Minion that is 3¾ Inches in her Bore, requires a Shot of 3 Inches Diameter; I demand the Weight of the Shot, the Weight of the Powder for Service, and the Length of the Cartridge.

For the Weight of the Shot, ſay, as 64 the Cube of 4 Inches, is to 9℔, So is the Cube of 3 Inches 27 to its Weight.

```
64———9———27                       51
          9  ℔.   ou.             16
     ———————                     ———
     64)243(3—12¾                306
        192                       51
     ————————                64)816(12 Ounces.
       51                       176
                                ———
                                 48
```

```
                 ℔.  ou.
5———4———3 : 12
16               16
——               ——
80               60
 8                8
——               ——
640             480
                  4
           640)1920(3℔ the Powder for Service.
               0000
```

To find the Length of the Cartridge, to 4 times the Cube of the Diameter of the Shot add $\frac{1}{7}$ of $\frac{1}{2}$ the Cube, the Sum will be the Drams contained; then as the Drams are to the Diameter of the Shot, ſo are the Drams contained in the Powder for Service to the Length of the Cartridge.

℔.
27 7)14(2 3
4 .. 16
108 48
2 In. 8
Dra. 110 —— —— 3 —— —— 384
3
110)1152(10,$\frac{4}{10}$ length of
..520(the Cartridge
·80

The Weight of the Shot is 3lb. 12 ou. the Powder for Service is 3lb. the Length of the Cartridge 10$\frac{4}{10}$ Inches, and 4 tenth Parts of an Inch.

A Saker that's $3\frac{1}{4}$ Inches in her Bore, requires a ſhot of $3\frac{1}{2}$ Inches Diameter; I demand the Weight of the Shot, the Powder for Service, and the Length of the Cartridge. *Prob.* 2.

℔. 3,5
4 — 3 — 6 3,5
3 ℔. ou. 175
4)18(4 : 8 Powder 105
2 1225
3.5
6125
3675
℔. 42,875
64 —— —— 9 —— 9
64)385.875(6℔. the Weight of
..1 the Shot.

42.875
4
171,500 7)21.43(3
3

Dr. 174 —— 3,5 —— 576 Drams in 4lb. 8 ou.
3.5
2880
1728
174)20160(11,$\frac{5}{10}$ Inches
276
1020
150

The Weight of the Shot is 6lb. the Powder for Service is 4lb. 8 ou. the Length of the Cartridge is 11$\frac{5}{10}$ Inches.

Prob. 3. A 12 Pounder that's 4$\frac{5}{8}$ Inches in her Bore, requires a Shot that's 4$\frac{3}{8}$; I demand the Weight of the Shot, the Powder for Service, and the Length of the Cartridge.

4.375 The Diameter of the Shot
4.375
21875
30625
13125
17500
19140625 Square.
4.375
95703125
133984375
57421875
76562500
64 —— 9 —— 83.740234375 Cube
9 lb. p.
64)75366(11.77
113
496
486
38

3—2—11,77
2 lb. p.
3)2354(7,84
25
14
2

83.74 7)41.87(6 ℔.ou.
4 7 : 12
16

334.96 124
6 8

340 Drams —— 4.375 —— 992 Drams
992

8750
39375
39375

340)4340000(13 Inches
940

20

The Weight of the Shot is 11℔. 12 ou. the Powder for Service is 7℔. 12 ou. and the Length of the Cartridge is 13 Inches.

CHAP. XV.

ADmit a Saker that's 4¼ Inches in her Bore, and requires a Shot of 4 Inches; I demand the Weight of the Shot, the Powder for Service, and the Length of the Cartridge; the Weight of the Shot is 9 lb. in courſe. *Prob.* 4.

℔.
4 —— 3 —— 9
3

4)27(6℔.—12 ou. Powder for Service.
3

4

```
  4
 16
----
 64 the Cube of the Shots Diameter.
  4                            6 : 12
----                          16
                             ----
256          7)32(4           108
  4                             8
----           In.           ----
260 Drams——————4——————————    864
                                4
                             ----
                    260 )3456(13 2/10 Inches.
                         ·856(
                         ----
                         ·760
                         ----
                          240
                          ···
```

The Weight of the Shot is 9lb. the Powder for Service is 6lb. 12 ou. the Length of the Cartridge is 13$\frac{2}{10}$ Inches, and 2 tenth parts of an Inch.

Prob. 5. A Cannon that's $5\frac{1}{4}$ Inches in the Bore, requires a Shot that's 5 Inches Diameter; I demand the Weight of the Shot, the Powder for Service, and the Length of the Cartridge.

5
25
64——9——125
9
℔. ou.
64)1125(17 : 9 Shot.
485
37
16
222
37
592
16

℔. ou.
3——2——17 : 9
16 16
48 102
179
281
2 ℔. ou.
48)562(11 : 11
82
34
16
204
34
544
64
16

℔. ou.
11 : 11.
16
66
111
1
187
8

7)62(9

125
4
500
9
Drams 509——5——1496
5
509)7480(14,$\frac{6}{10}$ Inches.
2390
3540
486

Weight of the Shot is 17 ℔. 9 ou. the Powder for Service is 11 ℔. 11 ou. the Length of the Cartridge is $14\frac{6}{10}$ Inches. All theſe ſorts of Guns have the Weight of the Shot for Proof Powder, Braſs, or Iron.

Prob. 6. A 24 Pounder that's $5\frac{83}{100}$ Inches in her Bore, requires a Shot that's $5\frac{54}{100}$ Inches Diameter; I demand the Weight of the Shot, the Weight of the Powder for Proof and Service, with the Length of the Cartridge.

```
                                           5·54
                                           5·54
                                         ------
      ℔    ou.  dr.                        2216
6 : 4 : 23 : 14 : 8                        2770
                  4                       2770
  ----------------- ℔. ou.              -------
6)95 : 10 : 0(15 : 15                    306916
                                            554
                                        -------
                                        1227664
                                       1534580
                                      1534580
                                     ----------
64 ———— 9 ——————————————————————————  170,031464
                                       9   ℔.  ou.  dr.
                                     ------
                                  64 )1530(23 : 14 : 8
                                      250
                                     ----
                                      58
4 : 3 : 16                            16
                                     ----
   3                                  348
 -----
4) 48(12 ℔                             58
 ---                                 ----
   8                                  928
                                     ----
                                      288
                                     ----
                                       32
```

170

```
170               7 ) 85 ( 12
  4                   15
----               --------
680                    1
 12                --------
----                   .  ℔  ou.
692 Dr. ——————— 5,54 ———————12, 0
                            16
                           -----
                           192
                             8
                          ------
                          1536
                          5.54
                         -------
                          6144
                         7680
                        7680
                       ---------
             692 ) 8509,44 ( 12 3/10 Inches.
                   1589
                  ------
                   205,4
```

The Powder for Proof is 16℔.

The Powder for Service is 12℔.

The length of the Cartaidge is $12\frac{3}{10}$ Inches.

CHAP. XVI.

A Braſs Peece of Ordnance that's $6,\frac{12}{100}$ Inches in the Bore, requires a Shot that's $5,\frac{83}{100}$ Inches. This Peece of Braſs Ordnance ſhould be 9 Diameters of her Bore about her Breech at the Touch-hole, but ſhe is but 7 Diameters. I demand the Weight of the Shot.

```
         6 : 12                       6.12
              9                          7
        ---------                 ----------
22—7—55.08               22—7—42,84
              7                          7
        ---------                 ----------
22 ) 385,56 ( 17,5       22 ) 299.88 ( 13,6
     165                        79
    -----                     -----
     11                        138
                              -----
                                ..6
```

The Diameter of the Shot is 5,83 Inches and 83 hundred parts of an Inch, the Cube of which is 198.

64 : 9 : 198
9 ℔ p
64)1782(27,84. or 13 Ounces.
502
540
280
24

lb.
6 : 4 : 27.84
4 ℔ p
6)111 : 36(18,56
51
33
30
. . .

℔ p
4 : 3 : 18, 56
3 ℔ p
4)55, 68(13, 92
15
36
. .
8
.

The Weight of the Shot is 27 ℔ 13 ou. the Powder ſor Proof is 18 ℔ 9 ou. the Powder ſor Service is 13 ℔ 14 ou. This Powder ſor Proof and Service, is ſor the fortified Peece of Ordnance, having 9 Diameters of her Bore about the Breech at the Touch-hole.

But that ſor 7 Diameters about the Breech at the Touch-hole requires another Operation.

The Diameter of the true fortified Peece is 17,5 Inches at the Touch-hole, that of the unfortified is 13,6 Inches at the Touch-hole.

The Cube of 17,5 is 5359,37, the Cube of 13,6 is 2515,45; then ſay, as the Cube 5359,37, is to the Cube 2515,45, So is the Powder ſor Service 13 ℔ 14 ou. ſor the fortified, to the Powder ſor Service ſor the unfortified.

lb.

```
                   ℔
5359,37 —— 13,92 ———— 2515,45
                        13,29
                      ———————
                       503090
                     2253905
                     754635
                     251545    lb. p
                   ——————————
          5359,37 )350050640( 6,53
                   3215622..
                   —————————
                   .2848844
                    2679685
                   —————————
                     1691590
                     1607811
                   —————————
                     ..83779

  53
  16
 ———
 318
 53
 ———
8,48
```

To find the Length of the Cartridge.

```
    195          7 ) 97 ( 14
      4              27
   ————
    780
     14                       lb.   cu
   ————
Dr.— 794 ———— 5,83 ———————— 13 : 14
                             16
                            ————
                             78
                            134
                              1
                            ————
                            222
                              8
                            ————
                           1776
                           5,83
                           ————
                           5328
                         14008
                         8880
                         ————————
                         10334,08

794 ) 10334,08 ( 13 Inches.
      2394
      ——————
      .. 12
```

The Length of the Cartridge for the fortified Peece is 13 Inches, then for the Length of the Cartridge of the unfortified, ſay,

As 794 Drams are to the Diameter of the Shot, 5,83 Inches; ſo are the Drams in 6 ℔ 8 ou. to the Length of the Cartridge.

```
                      6 : 8
                       16
                       96
                        8
                      104
                        8
794 ——— 5,83 — 832
                     5,83
                     2496
                    6656
                   4160
             794 ) 485056 ( 6,1
                   4764
                    865
                    794
                     71
```

The Length of the Cartridge is 6 $\frac{1}{10}$ Inches, and 1 Tenth Part of an Inch.

Prob. 8. Suppoſe the Diameter of the Metal of a Peece at the Touch-hole be 16 Inches, and the Diameter at the Bore 5 Inches and a Quarter, the Weight of the Peece 4850 Pound: Now ſuch a Peece will require 11 Pound of Powder for its Loading: But I find the Bore to be an Inch off its Place; thence I conclude the thinneſt Part of the Metal is 4 Inches and a Half-quarter, and the thickeſt 6 Inches and a Half-quarter, by which it appears, that one Side is 2 Inches thicker than the other. Now to find what Quantity of Powder will be a ſufficient Load for ſuch a Peece, it muſt be computed from the thinneſt Part of the Metal, which is here 4,375 Inches, which doubled is 8,75 Inches, to which add the Diameter at the Bore 5,25 Inches, the Sum is 14,00 Inches, which call the leſſer Diameter, and 16 the greater Diameter: And to find the Quantity of Powder, ſay, as the Cube of the greater Diameter, is to the Cube of the leſſer Diameter, ſo is 11 Pound of Powder, to the Powder to be allowed to the falſe bored Peece.

16 14
16 14

96 56
16 14

256 196
16 14

1536 784
256 196

4096 —— 11 —— 2744
11.

2744
2744

4096)30184($7,\frac{36}{100}$

36 15120

16 28320

216 3744
36

5,76

The Powder ſor the unfortified is 7 Pound and 5 Ounces.
The Weight of the Shot is 17,5 Pound and $\frac{1}{2}$.

```
                          lb.                  lb. ou.
                          11                   7,5
 125       7)62(9         16                   16
   4                      66                   117
 500                      11                     8
   9                      176                  936 Dr.
Dr. 509 ——— 5 ———           8
                          1408
                             5
                    509)7040(13,8 Inches, and 8 Tenths of
                        1950                   an Inch.
509 — 5 — 936
      936                 4230
509)4680(9 Inches          158
     ··99
```

The Length of the Cartridge for the fortified Peece is 13 Inches, and 8 Tenths of an Inch; for the unfortified is 9 Inches.

Prob. 9. If a Saker whoſe greateſt Thickneſs at the Touch-hole be 11 Inches and a half, and weigheth 1900 Pounds.

What will the Weight of another Saker be, whoſe greateſt Thickneſs at the Touch-hole is 8 Inches and 3 Quarters?

Say, as the Cube of 11 Inches and a half 1520,87.

Is to the Cube of 8 Inches and 3 Quarters 669,92.

So is 1900 Pound.

To the Weight required.

```
            1520,87 ——— 66992 ——— 1900
                                  1900
                        602928
                        66992
            1520,87)127284800(837 Pound fere
                    1216696
                    ··561520
                      456261
                      1052590
                      1064609
                      ·······
```

This is, if the two Peeces were of the ſame Metal, (as both Braſs) but if the Peece whoſe Weight you ſeek had been Iron: Then having performed all the former Work, as if they had been both Braſs, you muſt work another Proportion: For, the Proportion of the Weight between Braſs and Iron, being as 16 to 18, as 18 the Weight of Braſs is to 16 the Weight of Iron: So is 837 the Weight of the Peece if it had been Braſs, to 744 the Weight thereof, it being Iron.

18——16——837
16
5022
837
18) 13392 (744 Pound
79
72

CHAP. XVII.

IF a Saker of 3 Inches and 3 Quarters Diameter at the Bore, require 4 Pound of Powder for her Charge, what will a Demi-Cannon of 6 Inches and a half Diameter at the Bore, require for her Charge? *Prob.* 10.

The Cube of 3 Inches and 3 Quarters is 52,73.

And the Cube of 6 Inches and a half is 274,62.

Then ſay, as 52,73 the Cube of 3 Inches and 3 Quarters, is to 274,62 the Cube of 6 Inches and a half: So is 4 Pound, the Load ſor 3 Inches 3 Quarters, to 20,81 Pound the Load ſor 6 Inches and a Half. You are to note, That the Demi-Cannon ſhould be ſortified ſo well as the Saker: The Cube of the Diameter of the Demi-Cannon is 274,62, of the Saker 52,73, the Weight of the Saker 1600, what ſhould the Weight of the Demi-Cannon be?

Say, as 52,73 the Cube of the Bore of the Saker, is to 274,62 the Cube of the Bore of the Demi-Cannon: So is 1600 the Weight of the Saker, to 8332 the Weight that ſuch a Demi-Cannon ſhould be of, to bear ſuch a Charge proportionably to the Saker. But ſuppoſe the Demi-Cannon to be no more then 6000 Weight; then multiply 6000 by 20,81 the Charge already calculated, the Product will be 12486000, which divided by 8332, the Quotient will be 14,98; that is, 14 Pound of Powder and 15 Ounces.

A TABLE, wherein is deſcribed the Names of all ſorts of Ordnance, from the Cannon to the Baſe, alſo the Lengths, Breadths, Weights, Diameters, &c. of Powder, Shot, Ladle, &c. belonging to each Peece.

The Names of the ſeveral Peeces of Ordnance now in Uſe.	Diameter at the Bore	Weight	Long	The Load	Shots Diameter	Weight of Shot.	Length of Ladle	Breadth of Ladle
	Inches 100 parts	Pound weight	Feet 100 parts	Pounds 100 parts	Inches 100 parts	Pounds 100 parts	Inches 100 parts	Inches 100 parts
Cannon	8, 00	8000	12, 00	32, 50	7, 50	58, 00	24, 00	14, 75
Demi-CannonExtra	6, 75	6000	12 ,00	18, 00	6, 62	36, 00	22, 75	12, 00
Demi-Cannon Ordi.	6, 50	5600	10, 00 11, 00	17, 50	6, 16	32, 00	22, 00	12, 00
Culverin Extraord	5, 50	4800	10, 00 11, 00 13, 00	12, 50	5, 25	20, 00	16, 00	10, 00
Culverin Ordinary	5, 25	4500	12, 00	11, 37	5, 00	17, 31	15, 00	9, 50
Culverin of the leaſt Size	5, 00	4000	12, 00	10, 00	4, 75	14, 90	14, 25	9, 00
Demi Culverin Extraordinary	4, 75	3000	10, 00 12, 00 13, 00	8, 50	4, 50	12, 69	13, 50	8, 5
Demi-Culverin Ordinary	4, 50	2700	10, 00	7, 25	4, 25	10, 26	12, 75	8, 0
Demi-Culverin of the leaſt ſize	4, 25	2000	9, 00 10, 00	6, 25	4, 00	9, 00	12, 00	8, 00
Saker Extraord.	4, 00	1800	9, 00 10, 00	5, 00	3, 75	7, 31	11, 00	7, 25
Saker Ordinary	3, 75	1500	9, 00	4, 00	3, 50	6, 00	10, 50	6, 75
Saker of the leaſt ſize	3, 50	1400	8, 00	3, 37	3, 25	4, 75	9, 75	6, 50
Minion Large	3, 25	1000	8, 00	3, 25	3, 00	3, 75	9, 00	5, 00
Minion Ordinary	3, 00	750	7, 00	2, 50	2, 92	3, 25	8, 50	5, 00
Faucon	2, 75	750	7, 00	2, 25	2, 58	2, 50	8, 25	4, 50
Fauconet	2, 25	400	6, 00	1, 25	2, 01	1, 31	7, 50	4, 00
Rabonet	1, 50	300	5, 50	0, 75	1, 28	0, 50	4, 25	2, 50
Baſe	1, 25	200	4, 50	0, 50	1, 13	0, 50	4. 00	2, 00

A TABLE, ſhewing what Quantity of Powder in Pounds and Hundred parts of a Pound, will fill any Granado Shell whoſe Diameter is known.

Whole Inches in the Diameter.	Tenths of Inches.									
	0	1	2	3	4	5	6	7	8	9
1	00,01	00,02	00,03	00,04	00,05	00,06	00,07	00,08	00,10	00,12
2	00,14	00 16	00,18	00,20	00,23	00,26	00,28	00,32	00,37	00,41
3	00,45	00,50	00,55	00,61	00,66	00,72	00,79	00,86	00,92	01,00
4	01,08	01,16	01,25	01,34	01,44	01,55	01,64	01,75	01,86	01,9
5	02,11	02,22	02,37	02,51	02,65	02,80	02,96	03,12	03,29	03,46
6	03,64	03,83	04,02	04,17	04,42	04,63	04,84	05,07	05,30	05,54
7	05,78	06,03	06,29	06,56	06,83	07,11	07,40	07,70	08,00	08,31
8	08,65	08,96	09,30	09,64	09,97	10,35	10,73	11,10	11,30	11,89
9	12,29	12,70	13,13	13,56	14,00	14,45	14,92	15,39	15,87	16,36
10	16,86	17,05	17,89	18,42	18,97	19,52	20,08	20,66	21,24	21,83
11	22,44	23,06	23,69	24,32	24,98	25,64	26,32	27,00	27,70	28,41
12	29,14	29,87	30,57	31,37	32,15	32,93	33,72	34,53	35,35	36,19
13	37,12	37,91	38,77	39,67	40,65	41,48	42,41	43,26	44,31	45,28
14	46,26	47,26	48,27	49,30	50,34	51,40	52,47	53,56	54,66	55,77
15	57,90	58,04	59,21	60,39	61,58	62,78	64,01	65,24	66,50	67,73
16	69,06	70,36	71,68	73,02	74,37	75,74	77,12	78,53	79,94	81,38
17	83,00	84,48	85,97	87,48	89,00	90,55	92,11	93,69	95,29	96,91
18	98,54	100,19	101,86	103,55	105,26	106,97	108,73	110,49	112,27	114,07
19	115,87	117,79	119,59	121,47	123,37	125,29	127,22	129,33	131,16	133,15
20	135,17	137,21	139,27	141,35	143,45	145,57	147,71	149,87	152,05	154,25
21	156,48	158,73	160,99	163,28	165,59	167,92	170,28	172,65	175,05	177,93
22	179,92	182,38	184,87	187,38	189,91	192,46	195,04	197,64	200,27	202,91

CHAP.

CHAP. XVIII.

IT hath been experimented in the Tower of *London*, that One Pound of Powder will fill 31 Cubical Inches and 600 Parts, which is a little above half one-tenth Part of an Inch: This being allowed, it will be no hard Matter to know what Quantity of Powder will fill the Concavity of any Granado Shell, or Cartridge.

For the Proportion will be,
As 31,06 Cubical Inches,
Is to One Pound of Powder;
So is any other Number of Cubical Inches,
To the Number of Pounds of Powder that will fill thoſe Inches, whether it be Granado Shell or Cartridge.

I ſhall give one Example by Arithmetick.

Admit the Diameter of the Concavity of a Granado Shell be 13 Inches; firſt cube the Diameter, then multiply the Cube by 11, and divide the Product by 21, the Quotient will be the Cubical Inches contained in that Cavity; then divide thoſe Cubical Inches by 31,06, the Quotient will be the Pounds of Powder that will fill that Shell.

```
          13
          13
          39
         13
         169
         13
         507
        169
        2197
        2197
21)24167(        31)1150,809(37,12
   31                220
   106                 38
    170                70
      200               8
        11
```

So I find that 37 Pound of Powder and 2 Ounces, ſere, will fill the Concavity of the Granado Shell propoſed.

How to fill Cartridges.

The Diameter of the Cartridge, and the Pounds of Powder that will load the Peece, being known, to find the Length of the Cartridge when filled.

Let the Diameter given be 6,3 Inches, and 3 Tenth Parts of an Inch, and let the Quantity of Powder be 14,5, *(i. e.)* 14 Pound and a Half, and let it be required to find how high the Cartridge muſt be filled, that it may hold juſt ſo much Powder.

Firſt find the Area of the Circle of the Cartridge; then multiply the Square of the Diameter by 11, and divide the Product by 14, the Quotient will be the Area.

6,3
6,3
189
378
3969
3969
14) 436,59 (31,18
16
25
119
7

The Area of the Circle is 31 Inches and 18 hundred parts of an Inch.

Example.

The Area thus ſound, the Weight of Powder for Loading 14,5 Pound, and the Number of Cubical Inches in one Pound of Powder, *viz.* 31.06 known: to find how high the Cartridge muſt be filled,

This is the Proportion.

As the Inches in the Area of the Circle 31,18,
Is to the Powder allowed for Loading 14,5 Pound;
So are the Cubical Inches in one Pound of Powder 31,06,
To the height of the Cartridge to be filled.

31.18   14,5   31,06
14,5
15530
12424
3106
31,18) 450,370 (14,44
13857
13850
13780
1308

The Cartridge muſt be filled 14 Inches and 44 hundred parts of an Inch.

Inches in the Diameter of the Cartridge or Shot	Tenths of Inches in the Diameter of the Cartridge or Shot.									
	0 Inches 1000 P.	1 Inches 1000 P.	2 Inches 1000 P.	3 Inches 1000 P.	4 Inches 1000 P.	5 Inches 1000 P.	6 Inches 1000 P.	7 Inches 1000 P.	8 Inches 1000 P.	9 Inches 1000 P.
2	9,889	8,970	8,173	,471	6,868	6,330	5,852	5,427	5,046	4,704
3	4,395	4,117	3,863	3,641	3,432	3,229	3,053	2,890	2,740	2,601
4	2,473	2,353	2,243	2,141	2,044	1,954	1,879	1,791	1,717	1,648
5	1,582	1,522	1,463	1,408	1,357	1,308	1,258	1,218	1,175	1,127
6	1,099	1,063	1,629	0,996	0,966	0,930	0,908	0,881	0,855	0,831
7	0,806	0,785	0,763	0,742	0,722	0,703	0,685	0,667	0,650	0,634

The Uſe of this TABLE.

The Diameter of a Cartridge being given, to find how much of that Cartridge one Pound of Powder will fill.

Example 1.

Admit the Diameter of a Cartridge be 5 Inches, how much thereof will one pound of Powder fill?

Look for 5 Inches in the firſt Column on the Leſt-hand, againſt which ſtands—1,582, which is one Inch and 582 thouſand parts of an Inch, and ſo much will one pound of Powder fill of that Cartridge or Cylinder.

CHAP. XIX.

Example 2.

IF the Diameter of a Cartridge, or Cylinder of a Gun, be 4 Inches and 3 tenths, thereof will one Pound of Powder fill. Look for 4 Inches in the firſt Column, and for 3 tenths in the Head of the Table, and againſt 4 and under 3, you ſhall find 2,141, that is 2 Inches and 141 thouſand parts of an Inch, and ſo much will one pound of Powder fill.

Example 3.

The Diameter is 6,3 Inches, the quantity of Powder that will Load the Gun, 14,5 pound, being known, to find how much of the Cartridge muſt be filled to hold ſo much Powder.

Look for 6 Inches in the firſt Column, and for 3 in the head of the Table; and againſt 6, and under 3, you ſhall find 0,996; that is 0 Inches, but 996 thouſand parts of an Inch, and ſo much will one pound of Powder fill. Now if you multiply 0,996 by 14,5 (the quantity of Powder to Load the Gun) the Product will be 14,44, that is 14 Inches and 44 hundred parts of an Inch, and ſo high muſt the Cartridge be filled; agreeable to the former *Example.*

A TABLE ſhewing the weight of any ſhot of Iron, Lead, or Stone, from 2 Inches to 8 Inches Diameter.

Inches	Quarters	Lead		Iron		Stone	
		po.	ou.	po.	ou.	po.	ou.
2	0	1,	11	1,	2	0.	6.
	1	2	5½	1,	9	0.	9
	2	3	4½	2,	3	0.	13
	3	4	5½	2,	14½	1.	1
3	0	5	10	3,	12	1.	8
	1	7	3½	4,	13	1.	12
	2	9	00	6,	00	2.	4
	3	11	1¾	7,	6½	2.	12
4	0	13	8	9	00	3.	6
	1	16	2½	10,	12¼	4.	8
	2	19	3	12,	12¾	4.	12½
	3	22	9½	15,	1	5.	10
5	0	26	5½	17,	9	6.	9¼
	1	30	7½	20,	5	7.	9½
	2	35	1	23,	6	8.	12½
	3	40	00	26,	11	10.	2
6	0	45	9	30,	6	11.	6¼
	1	51	7½	34,	5	12.	13⅞
	2	57	13½	38,	9	14.	7¼
	3	64	12	43,	3¾	16.	3
7	0	72	4½	48,	3½	18.	1
	1	80	8½	53,	11	20.	6
	2	88	15½	59,	5	22.	3⅞
	3	98	2½	65,	7	24.	1
8	0	108	00	72,	00	27.	00

By this Table you may ſee that if a Gun carry a ſhot of 5 Inches and a half Diameter, that ſhot if of Lead, will weigh 35 pound 1 ou. if of Iron 23 pound 6 ou. if of Stone 8 pound 12 ou. and a half: Note, the Stone here meant is Marble, Pebble, and ſuch like, other Stone being more ſoft and porous; and conſequently lighter.

Alſo note, that in loading your Gun for a ſhot, you are not to give her the ſame Charge of Powder as for one of Lead or Iron, but abate according as the proportion of Metals are.

The proportion of Lead to Iron, is as 2 to 3, for a ſhot of 4 Inches Diameter of Lead will weigh 13 pound and a half, and a ſhot of 4 Inches of Iron will weigh 9 pound.

As 2 is to 3: So is 9 pound
3
2)27(13 pound
·7
1. 8 ounces.

Iron is to Stone as 8 to 3. Lead is to Stone as 4 to 1.

If an Iron ſhot of 2 Inches Diameter weigh 1 pound and 2 ounces, how much ſhall a ſhot of Stone weigh that is 2 Inches Diameter?

As 8——3——18 ounces
3
8)54(6$\frac{1}{4}$ ou. that is 6 ou. and $\frac{1}{4}$ of an ou. or 12 drams.
6

If a ſhot of Lead that is 4 Inches Diameter weigh 13 pound 8 ounces, what ſhall a ſhot of Stone weigh that is 4 Inches Diameter?

℔. ou.
4——1——13— 8
4)13— 8(3℔ 6 ou. The ſhot of Stone will weigh 3 ℔. and ſix ounces.
1
16
8
4)24(
··

A Compoſition for the Fuſe of a Granado-Shell.

Take one Pound of Gun-powder, four Ounces of Salt-peter, one Ounce of Brimſtone, all beaten to Powder, ſift them ſeverally through a fine Searſe: Theſe Ingredients well mixed together makes your Compoſition fit for Uſe.

A Compoſition for a Hand Granado Shell. Firſt, fill thoſe ſmall Shells with fine Gun-powder, then make your Fuſes of one Pound of Powder, ſix Ounces of Salt-peter, and one Ounce of Charcole: Or if you would have them of leſs Durance, you may make them of the Compoſition.

For Great Granadoes. Knock the Fuſe up to the Head within $\frac{1}{4}$ of an Inch, which is only to find it out by in the Night; ſtop well the reſt of the Hole in the Granado (and other Flaws if any be) with ſoft Wax, then coat it with Pitch, leaſt it ſhould break with the Fall; and be ſure, that as ſoon as you have fired the Fuſe, you caſt the Granado out of your Hand.

The Ancient and Later Rules given for Gunners, to give Powder to great Ordnance of all Sorts, that are drawn on Carriages.

According to the Cuſtom in former Times, the loading of Powder.

IN ancient Times it is ſaid, that the great Chamber'd-Guns, that ſhot Stone-Ball, had for their Ordinary one pound of Powder to three pound and half, or at moſt four pound weight of their Ball. This was certainly the firſt Invention of Guns; and in regard they could not caſt Iron, they made their Guns, as Coopers do Cask, with Staves of Iron and Hoops. Likewiſe, that thoſe Guns that ſhot Iron-Ball, muſt have to every three pound of Iron-Ball one pound of Powder: And this they held for a general Rule, not examining the Fortification of their Peeces. Now at this Time Powder was made of all the three Ingredients equal, and therefore could not be ſtrong. But afterward it was found, that all Sort of Field-Ordnance, not being chamber'd, but true bored, ſhould be loaded in this manner, (*to wit*) The Gunner ſhall take the Diameter of the Ball, or the Diameter of the Bore of the Peece with a pair of Compaſſes; and this Diameter three times the Gunner muſt ſet off upon his Gun, from the Touch-hole toward the Muzzle; which diſtance being fill'd with Powder, Then, ſaid they, One pound of Powder was allow'd to two pound of Ball: This was the Rule of the primitive Gunners. But now in our Time Powder is ſo variouſly made, and the Difference is ſuch, that it is hardly poſſible to the beſt Judgment, to give a true Rule, what Powder is ſufficient either for Proof or Action; and therefore the Gunner ought to try his Powder before he load his Peece; for it is beyond all queſtion, that if the Powder be decay'd, there muſt be more of it uſed than of freſh dry Powder; but if Powder be of his Majeſty's Tower-Proof, as I am inform'd, that then the Gunner need not take near ſo much Powder to ſhoot among a Party of Men, not being at a great Diſtance, as the Peece would crave to batter a Fortication, or Wall, or Gate, or Ship.

But becauſe the young Gunner, that is not yet experimented in his Practice, may be taught how he ſhall load all manner of Guns; and that it is to be underſtood, that ordinarily thoſe that will be called *Gunners*, though not known in the Art, uſe to load their Guns with half the weight of the Ball of Powder: This they hold for a general Rule to all Guns; which Rule is not to be ſlighted on ſome Occaſions, with true bored, true fortified Ordnance, (yet it may be ſaid, they have this by Tradition) to hold this Rule, without adding to reinforced Ordnance, or deducting from thoſe that are leſſen'd of Metal; ſo that by this they not having any other Rule, diſcover their own Nakedneſs, or Emptineſs of Art; for I am perſuaded, that no experienced Gunner but will hold, that the Gunner ought to ſearch, try, and find the Nature and Fortification of a Gun or Guns, before he do hold himſef obliged to give a Gun Powder, and thereby to prove a true Charge of Powder for the ſame.

CHAP. XX.

The Reaſons why I give Guns Powder according to their Fortifications.

THESE firſt Rules were derived from the weight of Ball; but ſince the Rules were made from the weight of the Peece; for they held generally that four ounces of Powder was ſufficient for the Gunner to give a Braſs Gun, to every hundred weight for Service; and three ounces to every hundred weight of Iron Guns. Neither this nor the other being right, for I have ſeen Trumpet-bored Iron Guns of twelve hundred weight, that could not have half the allowed Powder that either of theſe Rules did allow of. And likewiſe I read the Cauſe of the Death of King *James* the Second of *Scotland*, was by the breaking of a great Gun at the Siege of *Rosburgh*.

For theſe and the following Reaſons, I do not hold with that common received Rule, than which many Gunners know no better, but to give Ordnance Powder by the weight of the Gun. For if there be a Peece of Ordnance of Iron weighing ſixteen hundred pound weight, likewiſe there is another Peece of the ſame Bore, and of the ſame weight: Now by the Rule of weight it muſt have the like Powder.

But will you conſider, for your Inſtruction, this Peece is longer, and having no more Metal in her than the other, of Neceſſity ſhe muſt be thinner of Metal; for what ſhe hath of the Length, ſhe muſt want of her Thickneſs, the Bore being both of one Denomination; and ſince ſhe is thinner, it followeth ſhe muſt not have ſo much Powder as the other.

Great Cautions to be obſerved in giving Guns Powder.

Likewiſe, if by the weight of Guns they ſhould have their Powder, why then do not Founders, where they now make them eight feet long, do not make them ten feet? For it is known to the World, that a Peece of ten feet long will ſhoot farther than a Peece of eight feet long, but not without equal Powder: Wherefore it is to be conſidered, they muſt be both of one Fortification; and being alike in ſtrength, the longeſt of the two ought to ſhoot fartheſt, becauſe more of her Powder is ſpent in Fire before ſhe deliver her Ball.

That Guns ought to be proportion'd in length to their Fortification.

Queſtion.

But ſome may demand what I mean by Fortified Ordnance?

Anſwer.

For their Fortification, know that there are Ordnance of ſeveral Fortifications, as is before ſhewn in *pag.* 41. where it is ſufficient to be underſtood; and therefore I ſet the Tables of their Powder here, by their Proportions and Shape, and ſhew how to underſtand the Fortifications of Guns, and alſo what Powder ought to be given to Guns according to their Fortifications: As firſt you ſee the Geo-

Curioſity is good, if a Man be not taught, he cannot be perfect.

metrical Demonſtration of *Archimedes's* Proportion in *pag.* 40. how fitly that doth give the true Proportion of all true Bored and true Fortified Iron Ordnance.

Now to be capable of the ſame Proportion Arithmetically, the Proportion is, As 22 the Circumference is unto 7 the Diameter: So muſt 11 the Number of Times which the Diameter of the Bore meaſured about her Breech be, to a Number ſought for; which by the Work I find to be 3 $\frac{1}{2}$ Diameters of the Bore, which this Peece is of Diameter at the Touch-hole.

```
22        7        11
                    7          22(77(3 11/22 = 1/2
                  ———            (66(
                   77            ———
                                  11
```

Cometh 3 and $\frac{11}{22}$ which is equal to $\frac{1}{2}$.

Rules to find the Thickneſs of a True-Bored Gun in one Side Metal, by all the Diameter.

Whilſt the Bore itſelf is one of the Diameters, that being deduced from 3 $\frac{1}{2}$, reſts 2 $\frac{1}{2}$, whereby 1 $\frac{1}{4}$ is the thickneſs of that Peece in one ſide Metal; and becauſe theſe be the Ordnance of Iron, by which the Ground-Rule may be and ordinarily is laid down, to give Guns their Powder of other Fortifications; for you muſt know that there are ſome leſſened, as thinner Fortified, and ſo cannot have the ſame proportion of Powder, though they ſhoot one and the ſame Ball: Likewiſe there are reinforced or thicker Ordnance at the charged Cylinder, which ſhoot the ſame Ball, and muſt have more Powder: So you may ſee, that the Iron Peece is 11 Diameters of the Bore about the Breech, 9 Diameters at the Trunions, and 7 at the Neck.

The true Proportion of a true Bored, and true Fortified Peece of Ordnance.

Likewiſe the Braſs Peece is no thicker at the charged Cylinder, than the Iron Peece is at the Trunions, yet ſhoots the ſame Ball, and muſt have the ſame Powder; her Proportion is 9 Diameters of the Bore about the Breech, 7 about the Ears, and 5 about the Neck.

Seeing you have the Proportion of theſe true Fortified Ordnance; now it followeth of Neceſſity that the Powder of all ſuch Ordnance ſhould be known: And as writing at length would be tedious, therefore I have calculated Tables both for Proof and Action, not denominating the Names or Weight of theſe Ordnance.

But thus fortified with 11 Diameters of the Bore about the Breech, if Iron Ordnance, ſhooting from one pound Ball to 48 pound.

Alſo the ſame Tables will ſerve for Braſs Ordnance, being Fortified with 9 Diameters of the Bore about the Breech, by what Name ſoever you define them, ſhooting from one pound Ball, to 48 pound Ball.

The Weight of the Ball and Fortification of Ordnance, are true Rules to give Guns their Powder.

Hereby it is clear, That we are not to examine the Weight of Ordnance, and thereby to give them Powder; but Inſpection is to be had to the Fortification of all Sorts of Ordnance, as alſo to their weight of Ball: To find the Ball fitting a Peece, by extracting the Wind Geometrically, whereby you may have the true Diameter of the Peece, and by the Diameter you may find the weight of the Ball; as ſhall be ſhewn at large in its Place, in *Tables*, *Scale*, or *Height-Rule*, and alſo *Arithmetically*.

But in regard there hath never any Pains been taken for regulating the true Powder for Ordnance, I have therefore ſet down theſe Tables following, for Powder for *Proof* and *Action*, of True-Bored and True-Fortified Ordnance.

Table for Proof Powder, for True-Bored and True-Fortified Ordnance, either of Braſs or Iron.

B	P		B	P		B	P	
1	1	00	17	11	12	33	22	00
2	2	00	18	12	00	34	22	10
3	3	00	19	12	11	35	23	05
4	4	00	20	13	06	36	24	00
5	5	00	21	14	00	37	24	10
6	6	00	22	14	11	38	25	05
7	7	00	23	15	05	39	26	00
8	8	00	24	16	00	40	26	10
9	8	12	25	16	11	41	27	05
10	9	08	26	17	05	42	28	00
11	10	00	27	18	00	43	28	10
12	10	08	28	18	11	44	29	05
13	10	14	29	19	05	45	30	00
14	11	12	30	20	00	46	30	10
15	11	35	31	20	10	47	31	05
16	11	08	32	21	05	48	32	00

In this Table you have the weight of Ball, in the firſt, third, and fifth Columns, and is marked with the Letter B; and in the ſecond, fourth, and ſixth Columns, the Powder to prove theſe Guns, which is marked with the Letter P, being True-Bored and Fortified, Braſs 9, and Iron 11 Diameters of the Bore about the Breech.

Table for Action, of True-Bored and True-Fortified Ordnance, either of Braſs or Iron.

B	P		B	P		B	P	
1	0	10	17	7	11	33	14	10
2	1	02	18	8	00	34	15	02
3	1	12	19	8	07	35	15	09
4	2	05	20	8	14	36	16	00
5	3	00	21	9	05	37	16	07
6	3	09	22	9	12	38	16	14
7	4	03	23	10	03	39	17	05
8	4	12	24	10	10	40	17	12
9	5	02	25	11	01	41	18	03
10	5	06	26	11	08	42	18	10
11	5	10	27	12	00	43	19	01
12	6	00	28	12	07	44	19	09
13	6	06	29	12	14	45	20	00
14	6	12	30	13	05	46	20	07
15	7	02	31	13	12	47	20	14
16	7	07	32	14	03	48	21	05

In this Table you have the weight of Ball, in the firſt, third, and fifth Columns, marked with the Letter B; and in the ſecond, fourth, and ſixth Columns, being marked with the Letter P, the Powder for Action, for the Guns being Fortified, as beforeſaid, either Braſs or Iron.

Having ſhewn the Proportion of theſe Ordnance, and their due Powder, both for Proof and Action, it is now neceſſary to know the Proportion of their Ladles, Rammers, and Sponge-heads.

Firſt, Know that all True-Fortified Ordnance have not one proportion of Powder, as you may ſee by the foregoing Tables; neither muſt their Ladles be of equal Length or Breadth according to their Bore.

To make this the more clear, know that the Powder doth not lie in one proportioned Length in every True-Bored, True-Fortified Peece: For thoſe that ſhoot from one pound Ball to eight pound, the Powder lyeth three Diameters of the Ball in Length in a Cartridge, made on a Mold of the Diameter of the Ball.

The Proportion of Powder as ſuppoſed.

The Names of theſe Ordnance are theſe; a Baſe, a Fauconet, a Faucon, a Minion, a Saker, and a Demi-culvering.

Names of Guns.

Likewiſe for theſe Ordnance that ſhoot from eight pound Ball to eighteen pound, the Powder lyeth about two Diameters and a half long in a Cartridge, made on the Diameter of the Ball: Their Names are Demi-culvering, Quarter-Cannon, Culvering, or French Demi-Cannon.

Proportion of Powder and Names of Guns.

And for theſe True-Bored, True-Fortified Ordnance, that ſhoot from eighteen pound Ball to forty eight pound, the Powder lyeth two Diameters and a quarter long in a Cartridge, made on a Mold of the Diameter of the Ball: The Names of theſe Ordnance are Culvering, or French Demi-Cannon, Demi-Cannon Ordinary, Demi-Cannon Royal, French Cannon, and Cannon-Ordinary; and other Names they have, as Bazalisks, *&c.*

Proportion of Powder, and Names of Ordnance.

By what is before taught, you may know that the Ladles of Ordnance, though of one Fortification, ought not to be of one Proportion.

You muſt make the Ladles for ſmall Ordnance, *viz.* from one pound to eight, of three Diameters of the Ball in length, with as much as will nail it on the Ladle-head, and the breadth of thoſe Ladles ought to be of $1\frac{5}{6}$, one Diameter and five ſixth parts of the Ball: This Ladle nailed on a wooden head made of purpoſe, three fills thereof of Powder

Proportion of Ladles.

der will ſerve for Proof, and two fills of Powder will ſerve for Action to theſe Guns.

And the Ladles for True-Bored, True-Fortified Ordnance, ſhooting from eight pound Ball to eighteen, ought to be two Diameters and a half of the Ball long, with as much as will nail on the Rammer-head; and the Breadth of theſe Ladles, one and five ſixth parts of the Diameter of the Ball: Three of theſe Ladles full of Powder will ſerve for Proof, and two full of Powder will ſerve for Action.

Alſo thoſe Ladles for True-Bored, True-Fortified Ordnance, that ſhoot from eighteen pound Ball to forty-eight pound, or ſixty-four pound, ought to be two Diameters of the Ball long, and one and five-ſixth parts of the Diameter of the Ball broad: Three of theſe Ladles full of Powder will ſerve for Proof, and two full of Powder will ſerve for Action.

CHAP. XXI.

AS there are True-Bored, True-Fortified Ordnance, both of Braſs and Iron; *that is to ſay*, 11 Iron and 9 Braſs, ſo there are True-Bored Iron Ordnance of 10 Diameters of the Bore in the Breech, and Braſs of 8 Diameters of the Bore about the Breech.

And becauſe I know that ſome Gunners are not acquainted with *Arithmetick*, (for I have been at Sea with a Gunner that could not read) and ſo ſuch Men not being able to calculate the Powder of any Guns; therefore, for the publick Good of all, I have taken the Pains to calculate Tables for their Help: Theſe Tables ſerve for Iron of 10 Diameters of the Breech, and may well ſerve for Braſs of 8 of the Breech, as the Figures hereby ſheweth: For the Iron Gun is 10 Diameters of the Bore about the Breech, $8\frac{2}{11}$ at the Ears, and $6\frac{4}{11}$ at the Neck.

The Braſs Peece is $8\frac{2}{11}$ Diameters of the Bore about the Breech, $6\frac{4}{11}$ at the Ears, and $4\frac{6}{11}$ at the Muzzle: And their Diameters are wrought by the Rule of *Archimedes*; *that is to ſay*, As 22 is to 7, ſo is 10, $8\frac{2}{11}$, $6\frac{4}{11}$, or $8\frac{2}{11}$, $6\frac{4}{11}$ $4\frac{6}{11}$, to their Diameters: As you have it clearly demonſtrated in its proper place; For by their Fortifications they are to have their Powder, as the Tables following ſheweth.

This Table ſheweth Proof-Powder for Iron Ordnance of 10 *Diameters of the Bore, and for Braſs of* 8 $\frac{2}{11}$ *Diameters of the Bore about the Breech.*

B	P		B	P		B	P	
1	0	12	17	00	13	33	16	08
2	1	08	18	9		34	17	00
3	2	04	19	9	08	35	17	08
4	3	00	20	10	00	36	18	00
5	3	12	21	10	08	37	18	08
6	4	04	22	11	00	38	19	00
7	5	03	23	11	08	39	19	08
8	6	00	24	12	00	40	20	00
9	6	09	25	12	08	41	20	08
10	7	02	26	13	00	42	21	00
11	7	08	27	13	08	43	21	08
12	7	14	28	14	00	44	22	00
13	8	02	29	14	08	45	22	08
14	8	06	30	15	00	46	23	00
15	8	08	31	15	08	47	23	08
16	8	10	32	16	00	48	24	00

This Table ſheweth Powder for Action for Iron Ordnance of 10 *Diameters of the Bore about the Breech, and for Braſs of* 8 *Diameters about the Breech.*

B	P		B	P		B	P	
1	0	7½	17	5	12½	33	11	02
2	0	12	18	6	00	34	11	07
3	1	04	19	6	5½	35	11	12
4	1	12	20	6	10⅔	36	12	01
5	2	03	21	6	15⅚	37	12	06
6	2	10¾	22	7	05	38	12	11
7	3	02	23	7	10½	39	13	02
8	3	07	24	7	15¼	40	13	07
9	3	12	25	8	05	41	13	12
10	4	1½	26	8	10	42	14	01
11	4	3½	27	9	00	43	14	06
12	4	8½	28	9	05	44	14	11
13	4	12½	29	9	10½	45	15	00
14	5	1¾	30	10	01	46	15	05
15	5	5¾	31	10	06	47	15	10
16	5	8½	32	10	10	48	16	00

In the laſt preceding Tables, the firſt Table, or the Table next your left Hand, ſheweth the Weight of the Ball, in the firſt, third, and fifth Columns, and is marked with the Letter B; in the ſecond, fourth, and ſixth Columns, you have the Powder to prove theſe Guns, which are marked with the Letter P; being True-Bored and Fortified, as before-ſaid.

In the right Hand Table you have the Weight of the Ball, in the firſt, third, and fifth Columns, marked with the Letter B; and in the ſecond, fourth, and ſixth Columns, being marked with the Letter P, the Powder for Action for the Guns, being Fortified as before-ſaid, either of Braſs or Iron.

Now there are Ordnance of Iron Fortified with 9 Diameters of the Bore about the Breech, and Braſs of 7 about: And in regard I have ſeen divers Miſtakes about giving them Powder, even of Men profeſſing great Knowledge without Reaſon: Therefore I will here deſcribe theſe Tables following, to give them their due Powder. Lower Fortified than 9 of Iron, and 7 of Braſs, you ſhall hardly find a True-Bored Peece of Ordnance; The Iron Ordnance being 9 Diameters of the Bore about the Breech, 7 at the Trunions, and $5\frac{8}{11}$ at the Muzzle or Neck: The Braſs Ordnance of 7 Diameters of the Bore at the Breech, $5\frac{8}{11}$ about the Trunions, and $4\frac{7}{11}$ at the Neck.

This Table is the Proof for Iron Ordnance of 9 Diameters in the Breech, and Braſs of 7.

B	P		B	P		B	P	
1	0	8½	17	6	06	33	12	00
2	1	1½	18	6	09	34	12	06
3	1	10½	19	6	12	35	12	12
4	2	03	20	7	02	36	13	01
5	2	12	21	7	09	37	13	07
6	3	4½	22	8	00	38	13	13
7	3	13½	23	8	6½	39	14	03
8	4	04	24	8	12	40	14	09
9	4	13	25	9	02	41	14	15
10	5	3¼	26	9	6½	42	15	05
11	5	08	27	9	13	43	15	11
12	5	12	28	10	03	44	16	01
13	5	15¼	29	10	09	45	16	07
14	6	1½	30	10	15	46	16	13
15	6	2¾	31	11	05	47	17	03
16	6	04	32	11	10$\frac{4}{7}$	48	17	08

This Table is the Powder for Action for Iron of 9, and Braſs of 7 Diameters of the Bore about the Breech.

B	P		B	P		B	P	
1	0	5½	17	4	3½	33	8	00
2	0	10	18	4	06	34	8	4½
3	0	15	19	4	9¾	35	8	8½
4	1	04	20	4	13	36	8	13
5	1	10	21	5	00	37	9	01
6	1	15½	22	5	05	38	9	04
7	2	05	23	5	09	39	9	08
8	2	09	24	5	13	40	9	11
9	2	12	25	6	0¾	41	9	14
10	2	15½	26	6	4¾	42	10	00
11	3	1½	27	6	09	43	10	03
12	3	4½	28	6	13	44	10	5½
13	3	7¾	29	7	0¾	45	10	08
14	3	11	30	7	4½	46	10	12½
15	3	14¼	31	7	09	47	11	00
16	4	01	32	7	13½	48	11	03

Now as theſe are the Tables for True-Fortified, and leſſened in Metal, I hold convenient to give Tables for Re-inforced Ordnance: Theſe have commonly, being Braſs, 10 Diameters of the Bore about the Breech, and Iron 12 about the Breech. And though to ſome theſe Tables may ſeem fooliſh, I have ſeen thoſe who have been eſteemed Able Gunners, that knew not how to give ſuch Guns Powder; yea, they have in my Preſence wagered, and not one of them knew what they wagered concerning two ſuch Guns lying at the Head of *Terveer* conſer; where amongſt ſix Gunners one only underſtood to give theſe two Guns their true Powder; as, at the Diſcuſſion, a Gentleman of the Ordnance to the States did manifeſt in favour of the one Man.

How many Gunners at the Wager, and but one capable.

I alſo have been in Conteſt with one profeſſing great Art, and was a rare Perſon in Art: Yet in the Caſtle of *Edenburgh*, there was a Gally-Gun of Braſs that did ſhoot 28 pound Ball; and thereby he did conclude that Peece to have 13 or 14 pound of Powder for Action: In hearing this Expreſſion I did laugh: The Gentleman was offended, and asked if I could teach him, (it was but in Diſdain); I anſwered, Sir, if you know not better than you expreſs, I am ſure I am able to teach you in this Point: Whereupon he went out at the Caſtle-Gate, and was ever mine Enemy from that Time forth. And to ſatisfy the Reader, I will give the Dimenſions of that Peece: She was but 7 Diameters of the Bore about the Breech, and $5\frac{1}{2}$ about the Muzzle; for ſhe was plain without Rings, except the Baſe and Muzzle-Rings, or Corniſh-Rings; ſo that by her Fortification ſhe could ſuffer but 6 pound and 13 ounces of Powder; and with ſo much I have cauſed her to be diſcharged divers Times, and could do Service with this Peece, which could not be done with a True-Fortified Peece; for with this Peece I have ſhot over the Steeple of *Edenburgh*, and the Ball hath fallen at the next Lodging where *Cromwell* did lie. And this I did for three Times together, till our Governour diſcharged me to ſhoot any more for troubling his Friend. Therefore I ſay, An able Man may be miſtaken of a Gun, when he neither knoweth the Fortification nor Proportion how to work to give a Peece Powder.

This Diſpute was between a general perſon and a Gunner.

What may be done with a leſſened Peece, as if it were a Mortar-Peece.

So to avoid Trouble to Artiſts for calculating, and to inſtruct thoſe Gunners that are not capable of Calculation, I have here ſet down the Demonſtration of theſe Guns of Iron, having 12 about the Breech, and Braſs having near 10 Diameters about the Breech, and are called Reinforc'd Ordnance. The Figures following demonſtrate the true proportion of theſe Reinforc'd Ordnance, which require more Powder than True-Bored, True-Fortified Ordnance, as you may ſee by the Tables following; which Tables might have been firſt of all: But I obſerve that the Ground-Rule muſt be put in the firſt Place; and thoſe that do take their Dimenſions from it do follow, whether they be Reinforc'd or leſſened of Metal, ſuch as are formerly deſcribed.

Theſe following Tables are Tables for Reinforc'd Ordnance, which are ſuch as have more Strength of Fortification, and are more able to endure firing: Such as be the Bazalisk, Serpents, or Slings, &c. and are good to ſhoot with at a great Diſtance. Having, as I ſuppoſe, given a full Account of the true Allowance of Powder for all Sorts of True-Bored Ordnance, both for Proof and Action, whether they be Braſs or Iron Guns, it followeth, that the Gunner ought to know how to go to work with his Peece, when he is to apply theſe Tables, by which he is to give fire.

Theſe Rules are to be obſerved.

Firſt, He ſhall take a piece of Twine, which is to be well waxed, as the Shoemakers do their Thread, that it do not ſtretch nor ſhrink; then meaſure the Peece about at the Touch-hole betwixt the Rings, and taking with a Pair of Compaſſes the Diameter of the Bore at the Muzzle, meaſure the Twine how many Diameters of the Bore is contained about the Breech of the Peece; that keep in Memory. Now you are to know what Ball fits that Peece, as is plainly ſet down Geometrically; but may be exactly found in the Tables of Height and Weight of Shot, and in the Tables of Diameters of Bores, either Scots or Engliſh. When you have found the Diameter of the Ball, if you cannot arithmetically find the Weight by the Diameter of the Ball, then you may reſort to the Tables for ſuch Fortifications, and next the Weight of Ball you have the Weight of Powder for that Peece: But you muſt be ſure your Peece muſt be True-Bored, as is mentioned in *pag.* 76; for if the Peece be either taper'd, chamber'd, or trumpet-bored, theſe Tables will do no Service.

Proof Powder for Reinforc'd Ordnance, or Iron Guns of 12 *Diameters of the Bore about the Breech, and Braſs Guns near* 10 *Diameters.*

B	P		B	P		B	P	
1	1	05	17	15	01	33	28	08
2	2	09	18	15	05	34	29	10
3	3	10	19	16	07	35	30	08
4	5	01	20	17	05	36	31	08
5	6	08	21	18	02	37	32	04
6	3	05	22	18	15	38	33	01
7	9	01	23	20	00	39	34	02
8	10	06	24	20	12	40	35	00
9	11	06	25	21	09	41	35	12
10	12	05	26	22	08	42	36	08
11	12	15	27	23	07	43	37	08
12	13	10	28	24	12	44	38	05
13	14	01	29	25	01	45	39	04
14	14	07	30	26	00	46	40	02
15	14	10	31	26	14	47	41	00
16	14	14	32	27	10	48	41	12

In this Table you have the weight of Ball, in the firſt, third, and fifth Columns, and is marked with the Letter B; and in the ſecond, ſourth, and ſixth Columns, you have the Powder to prove theſe Guns, which is marked with the Letter P, being True-Bored and Fortified, as above-written.

Powder for Action of Reinforc'd Ordnance, or Iron Guns of 12 *Diameters of the Bore about the Breech, and Braſs near* 10 *Diameters about the Breech.*

B	P		B	P		B	P	
1	0	13	17	10	02	33	19	04
2	1	7½	18	10	05	34	19	14
3	2	4½	19	11	01	35	20	08
4	3	00	20	11	10	36	21	01
5	3	15	21	12	03	37	21	09
6	4	14	22	12	15	38	22	01
7	5	08	23	13	08	39	22	10
8	6	02	24	14	00	40	23	03
9	6	10	25	14	08	41	23	12
10	7	02	26	15	00	42	24	06
11	7	06	27	15	12	43	24	14
12	7	15	28	16	03	44	25	08
13	8	05	29	16	12	45	26	03
14	8	14	30	17	04	46	26	13
15	9	06	31	18	01	47	27	04
16	9	12	32	18	10	48	28	14

In this Table you have the weight of Ball, in the firſt, third, and fifth Columns, marked with the Letter B; and in the ſecond, fourth, and ſixth Columns, you have the Powder for Action, which is marked with the Letter P, being True-Bored and Fortified, as above-written.

CHAP.

CHAP. XXII.

To find the Weight of an Iron Ball in Engliſh Inches Arithmetically for Scots Weight.

FOR thoſe that cannot find the Weight of the Ball by Arithmetick, I will here ſhew them a Rule, and alſo Tables, which I have calculated as well Decimally, as in Pounds, Ounces, and Drams, from eight parts to eight of an Inch of the Diameter of a Ball, unto ten Inches Diameter, both in Scots and Engliſh Weight, and alſo in Scots and Engliſh Inches, for the Artificial Gunner's more Eaſe.

It falls out many times that the Gunner cannot find Weights and Scales to weigh his Shot; it is therefore neceſſary the Gunner ſhould know how to find the Weight of his Shot Arithmetically; as thus, If you deſire to know the Weight of a Ball, whoſe Diameter is juſt Inches, without any Fraction or parts of an Inch, then you are to multiply the Diameter cubically; then double that Product, and divide the Total by 16, you have in the Quotient the Pounds that the Ball weigheth; and what Remainder you have over, you ſhall know that Remainder is Ounces.

Example.

There is a Ball of 4 Inches Diameter given, to find his Weight: The Cube of 4 is 64, which being doubled maketh 128; this 128 being divided by 16, (the Ounces in a Pound) the Quotient giveth 8, which is eight pound of Scots Weight which that Ball doth weigh.

Behold the Work.

```
  4
  4       16)128(8 lb.
---         )128(
 16        ----
  4         ...
---
 64
 64
---
128
```

Eight pound of Scots weight is the true weight of that Ball.

And becauſe every Gunner hath not his Arithmetick at his Fingers Ends, and alſo to eaſe the Artificial Gunner, I have taken the Pains to calculate theſe following Tables, both of Scots and Engliſh Weight and Meaſure, *&c.* as before-ſaid. I do not take them on truſt as others do, but have calculated them myſelf from the Ground Rules, and have given Credit to none, becauſe I never found any yet truly ſet forth.

Tables for Iron Ball, whoſe Diameters being meaſured with Engliſh Inches, are exactly calculated for Scots Weight, from Eight Parts to Eight Parts of Engliſh Inches, unto Ten Inch[illegible] Decimally.

B	Li.	Parts.	B	Li.	Parts.	B	Li.	Parts.	B	Li.	Parts.
⅛	00	00024	2⅝	02	26099	5⅛	16	82642	7⅝	54	41528
¼	00	00195	2¾	02	59961	5¼	18	08789	7¾	58	18555
⅜	00	00659	2⅞	02	97046	5⅜	19	41089	7⅞	61	04663
½	00	01562	3	03	37500	5½	20	79687	8	64	00000
⅝	00	03052	3⅛	03	81470	5⅝	22	24731	8⅛	67	04712
¾	00	05273	3¼	04	29102	5¾	23	76367	8¼	70	18945
⅞	00	08374	3¾	04	80542	5⅞	25	34741	8⅜	73	42847
1	00	12500	3½	05	35937	6	27	00000	8½	76	76562
1⅛	00	17798	3⅝	05	95435	6⅛	28	72290	8⅝	80	20240
1¼	00	24414	3¾	06	59180	6¼	30	51758	8¾	83	74023
1⅜	00	32495	3⅞	07	27319	6⅜	32	38550	8⅞	87	38062
1½	00	42187	4	08	00000	6½	34	32812	9	91	12500
1⅝	00	53638	4⅛	08	77368	6⅝	36	34692	9⅛	94	97485
1¾	00	66992	4¼	09	59570	6¾	38	44336	9¼	98	93164
1⅞	00	82397	4⅜	10	46753	6⅞	40	61890	9⅜	102	99683
2	01	00000	4½	11	39062	7	42	87500	9½	107	17187
2⅛	01	19946	4⅝	12	36645	7⅛	45	21313	9⅝	111	45825
2¼	01	42383	4¾	13	39648	7¼	47	63476	9¾	115	85742
2⅜	01	67456	4⅞	14	48218	7⅜	50	14136	9⅞	120	37085
2½	01	95312	5	15	62500	7½	52	73437	10	125	00000

In this Table you have eight Columns; in the firſt, third, fifth, and ſeventh Columns, there are the Inches, and eight Parts of Inches that the Diameter of the Ball doth contain, and are marked with the Letter B: And in the ſecond, fourth, ſixth, and eighth Columns, you have the Weight of theſe Diameters of Iron Ball in Scots Weight; under Li. you have Pounds, and under Parts you have the Decimal Parts of Pounds.

Tables for Iron Ball, whoſe Diameters being meaſured with Engliſh Inches, are exactly Calculated for Scots Weight, in Pounds, Ounces and Drams, from eight parts to eight parts of Engliſh Inches, unto 10 Inches.

B	Li.	Ou.	Dr.	B	Li.	Ou.	Dr.	B	Li.	Ou.	Dr.
1	00	02	00	4	08	00	00	7	42	14	00
1⅛	00	02	14	4⅛	08	12	06	7⅛	45	03	07
1¼	00	03	14	4¼	09	09	08	7¼	47	10	01
1⅜	00	05	03	4⅜	10	07	08	7⅜	50	02	04
1½	00	06	12	4½	11	06	04	7½	52	11	12
1⅝	00	08	09	4⅝	12	05	14	7⅝	55	06	10
1¾	00	10	11	4¾	13	06	05	7¾	58	02	15
1⅞	00	13	03	4⅞	14	07	11	7⅞	61	00	12
2	01	00	00	5	15	10	00	8	64	00	00
2⅛	01	03	03	5⅛	16	13	04	8⅛	67	00	12
2¼	01	06	12	5¼	18	01	06	8¼	70	03	00
2⅜	01	10	13	5⅜	19	06	09	8⅜	73	06	14
2½	01	15	04	5½	20	12	12	8½	76	12	04
2⅝	02	04	03	5⅝	22	03	15	8⅝	80	03	04
2¾	02	09	09	5¾	23	12	03	8¾	83	11	13
2⅞	02	15	08	5⅞	25	05	09	8⅞	87	06	01
3	03	06	00	6	27	00	00	9	91	02	00
3⅛	03	13	00	6⅛	28	11	09	9⅛	94	15	10
3¼	04	04	10	6¼	30	08	04	9¼	98	14	14
3⅜	04	12	14	6⅜	32	06	03	9⅜	102	15	15
3½	05	05	12	6½	34	05	04	6½	107	02	11
3⅝	05	15	04	6⅝	36	05	09	9⅝	111	07	05
3¾	06	09	07	6¾	38	07	01	9¾	115	13	11
3⅞	07	04	06	6⅞	40	09	14	9⅞	120	05	15

In this Table you have ſix Columns; in the firſt, third, and fifth Columns, there are the Inches, and eight parts of Inches, that the Diameter of the Ball doth contain, and are marked with the Letter B; and in the ſecond, fourth, and ſixth Columns, you have the Weight of theſe Diameters of Iron Ball in Scots Weight; under Li. you have Pounds, under Ou. Ounces, and under Dr. Drams.

The Height-Rule you have on the ſide of the Quadrant, which proves this Table.

This will be Admirable to ſome Gunners, and eſpecially Engliſh, becauſe their Weight and the Scots Weight doth not hold alike; I have peruſed the Tables of Weight by moſt of the Authors of Gunnery, and I find them all to agree, and hold firm, as Mr. *Nye* writeth. But indeed I find nothing of ingenuity, for a Man to copy a Table from anothers Works, and never examine the Truth of the Work; But I have made uſe of their own Ground-Rule, and find not one of them to have wrought it, or ſet the Table down truly.

I will here ſet down the Ground-Rule by which they are to make their Table, that the Ingenuous Gunner may Correct it himſelf at his pleaſure.

Mr. Nye *ſays, That two Inches Diameter, is* 1 *pound* 1 *ounce.*

Thus they ſet it down, 2 Inches Diameter give 1 pound 1 ounce.

Now having this for a Rule, you may, if you pleaſe, make a Table.

Behold the Work.

```
              ℔         Inches.
If 2 gives  1 1/16, What 2 1/4                  On. Dr.
  ———        ————        ————     512)12393(24   3
   8         17           9           1024
   8                      9           ————
  ———                    ————         2153
  64                     81           2048
   8                      9           ————
  ———                    ————          105
 512                    729             16
                         17           ————
                       —————           630    512)1680(3
                        5103           105        1536
                        729           ————        ————
                       —————          1680         144
                        12393
```

Where you ſee, if 2 Inches give one pound one ounce, 2¼ Inches giveth 1 pound, 8 ounces, and 3 drams, whereof 16 make an ounce. And by their Tables, becauſe they would be near the Right, they ſet down 4 Inches to give 8 pound 15 ounces; where by this Work it will be but 8 pound 8 ounces.

But there is another more ſure way, by this Work following: Say, As 2 Inches is to one pound two ounces: So is the Diameter given, unto the Weight required.

The trueſt Rule.

Behold the Work.

For by this Rule I have Calculated the Table following.

Inches.	lb.	Inches.
2	$1\frac{2}{16}$	3
2	18	3
4		9
2		3
8		27
		18
		216
		27
		486

$8\,)\,486\,(\,60$

48

$\cdot\cdot 6$

$3\frac{12}{16} \,\Big|\, \frac{3}{4}$

$16\,)\,60\,(\,3$ lb. 12 ounces, 12 drams,

48 or $\frac{3}{4}$ of an ounce.

12

Tables for Iron Ball, whoſe Diameters being meaſured with Engliſh Inches, are exactly calculated Decimally for Engliſh Weight, from Eight Parts to Eight Parts of Engliſh Inches, unto Ten Inches.

B	Li.	Parts.	B	Li.	Parts.	B	Li.	Parts.	B	Li.	Parts.
⅛	00	00027	2⅝	02	54361	5⅛	18	92972	7⅝	62	34219
¼	00	00220	2¾	02	92456	5¼	20	34888	7¾	65	45874
⅜	00	00742	2⅞	03	34177	5⅜	21	83725	7⅞	68	67746
½	00	01758	3	03	79687	5½	23	39648	8	72	00000
⅝	00	03433	3⅛	04	29153	5⅝	25	02823	8⅛	75	42801
¾	00	05933	3¼	04	82739	5¾	26	73413	8¼	78	96313
⅞	00	09421	3⅜	05	40610	5⅞	28	51584	8⅜	82	60703
1	00	14062	3½	06	02930	6	30	37500	8½	86	36133
1⅛	00	20023	3⅝	06	69864	6⅛	32	31336	8⅝	90	22769
1¼	00	27466	3¾	07	41577	6¼	34	33228	8¾	94	20776
1⅜	00	36557	3⅞	08	18234	6⅜	36	43369	8⅞	98	30319
1½	00	47461	4	09	00000	6½	38	61914	9	102	51562
1⅝	00	60342	4⅛	09	87039	6⅝	40	89029	9⅛	106	84671
1¾	00	75366	4¼	10	79517	6¾	43	24878	9¼	111	29810
1⅞	00	92697	4⅜	11	77597	6⅞	45	69626	9⅜	115	87143
2	01	12500	4½	12	81445	7	48	23437	9½	120	56836
2⅛	01	34940	4⅝	13	91226	7⅛	50	86478	9⅝	125	39053
2¼	01	60181	4¾	15	07104	7¼	53	58911	9¾	130	33960
2⅜	01	88388	4⅞	16	29245	7⅜	56	40903	9⅞	135	41721
2½	02	19727	5	17	57812	7½	59	32617	10	140	62500

In this Table you have eight Columns ; in the firſt, third, fifth, and ſeventh Columns, are the Inches and eight parts of Inches that the Diameter of the Ball doth contain, and are marked with the Letter B; and in the ſecond, fourth, ſixth, and eighth Columns, you have the Weight of theſe Diameters of Iron Ball in Engliſh Weight; under Li. you have Pounds, and under Parts, you have the Decimal Parts of Pounds.

Tables for Iron Ball, whoſe Diameters being meaſured with Engliſh Inches, are exactly Calculated for Engliſh Weight, in Pounds, Ounces, and Drams from eight parts to eight parts of Engliſh Inches, unto 10 Inches.

B	Li.	Ou.	Dr.	B	Li.	Ou.	Dr.	B	Li.	Ou.	Dr.
1	00	02	04	4	09	00	00	7	48	03	12
1⅛	00	03	03	4⅛	09	13	15	7⅛	50	13	13
1¼	00	04	06	4¼	10	12	12	7¼	53	09	07
1⅜	00	05	14	4⅜	11	12	07	7⅜	56	06	09
1½	00	07	10	4½	12	13	00	7½	59	05	03
1⅝	00	09	10	4⅝	13	14	10	7⅝	62	05	08
1¾	00	12	01	4¾	15	01	02	7¾	65	07	05
1⅞	00	14	13	4⅞	16	04	11	7⅞	68	10	13
2	01	02	00	5	17	09	04	8	72	00	00
2⅛	01	05	09	5⅛	18	14	14	8⅛	75	06	14
2¼	01	09	10	5¼	20	05	09	8¼	78	15	07
2⅜	01	14	02	5⅜	21	13	06	8⅜	82	09	11
2½	02	03	00	5½	23	06	05	8½	86	05	13
2⅝	02	08	11	5⅝	25	00	07	8⅝	90	03	10
2¾	02	14	13	5¾	26	11	12	8¾	94	03	05
2⅞	03	05	07	5⅞	28	08	04	8⅞	98	04	14
3	03	12	12	6	30	06	00	9	102	08	04
3⅛	04	04	11	6⅛	32	05	00	9⅛	106	13	09
3¼	04	13	04	6¼	34	05	05	9¼	111	04	12
3⅜	05	06	08	6⅜	36	06	15	9⅜	115	13	15
3½	06	00	08	6½	38	09	14	9½	120	09	02
3⅝	06	11	03	6⅝	40	14	04	9⅝	125	05	04
3¾	07	06	10	6¾	43	04	00	9¾	130	05	07
3⅞	08	02	15	6⅞	45	11	02	9⅞	135	06	11

In this Table you have ſix Columns, in the firſt, third, and fifth Columns, there are the Inches and eight parts of Inches, that the Diameter of the Ball doth contain, and are marked with the Letter B; and in the ſecond, fourth, and ſixth Columns, you have the Weight of theſe Diameters of Iron Ball in Engliſh weight; under Li. you have Pounds, under Ou. Ounce, and under Dr. Drams.

By which Work and Tables you may examine any other Weight, if you will compare.

Example.

As in the preceding Example, 3 Inches Diameter giveth 3 pound 12 ounces and 12 drams, as you may ſee by the Work.

Alſo, I demand what giveth 4 Inches Diameter.

```
Inches.    ℔      Inches.
  2      2 2/8      4
  2      ----       4
 ---      18       ---
  4                16
  2                 4                33
 ---               ---               1152(144(9 pound.
  8                64                888( 16(
                   18
                   ---               Anſwer, It giveth 9 ℔.
                   512
                   64
                   ---
                  1152
```

Another Example.

If 4 Inches of Diameter give 9 pound weight, what ſhall 8 Inches give? Anſwer, 72 pound.

```
Inches.      ℔      Inches.
  4          9        8
  4                   8
 ---                 ---        64)4608(72 ℔
 16                  64           )448·(
  4                   8            ---
 ---                 ---            128
 64                  512            128
                       9            ---
                     ---            ...
                     4608
```

Another

Another Example with a Fraction.

If 4 Inches of Diameter give 9 pound, what ſhall $6\frac{1}{4}$ Inches give.

Inches. 4
4
16
16
16
96
16
256

℔ 9

Inches. $6\frac{1}{4}$
27
27
189
54
729
27
5103
1458
19683
9
177147

256)177147(691
1536..
2354
2304
507
256
251.

16)691(43 ℔
64.
51
48
3 Ounces.

I Anſwer, This Ball of $6\frac{1}{4}$ Inches Diameter, weigheth 43 pound 4 ounces *fere*; which proves both the Work and Tables to be true and juſt.

Obſervation.

The difference betwixt Scots and Engliſh Weight.

It is to be obſerved, That as there is a difference betwixt Scots and Engliſh Weight, *viz.* as 8 to 9, ſo is there likewiſe a difference between Scots and Engliſh Inches, which is as 9 to 10; that is to ſay, 9 Engliſh Inches make 10 Scots Inches; as it appeareth in the Tables following.

Tables for Iron Ball, whoſe Diameters being meaſured with Scots Inches, are exactly calculated Decimally for Scots Weight; from Eight Parts to Eight Parts of Scots Inches, unto Ten Inches.

B	Li.	Parts.	B	Li.	Parts.	B	Li.	Parts.	B	Li.	Parts.
⅛	00	00018	2⅝	01	64826	5⅛	12	26646	7⅝	40	39774
¼	00	00142	2¾	01	89512	5¼	13	18607	7¾	42	41726
⅜	00	00481	2⅞	02	16546	5⅜	14	15054	7⅞	44	50299
½	00	01139	3	02	46037	5½	15	16092	8	46	65600
⅝	00	02225	3⅛	02	78091	5⅝	16	21829	8⅛	48	48877
¾	00	03844	3¼	03	12815	5¾	17	32372	8¼	51	16811
⅞	00	06105	3⅜	03	50315	5⅞	18	47826	8⅜	53	52935
1	00	09112	3½	03	90698	6	19	68300	8½	55	96214
1⅛	00	12975	3⅝	04	34072	6⅛	20	93899	8⅝	58	46754
1¼	00	17798	3¾	04	80542	6¼	22	24731	8¾	61	04663
1⅜	00	23689	3⅞	05	30216	6⅜	23	60903	8⅞	63	70047
1½	00	30755	4	05	83200	6½	25	02520	9	66	43012
1⅝	00	39102	4⅛	06	39601	6⅝	26	49691	9⅛	69	23667
1¾	00	48837	4¼	06	99527	6¾	28	02521	9¼	72	12117
1⅞	00	60068	4⅜	07	63083	6⅞	29	61118	9⅜	75	08469
2	00	72900	4½	08	30377	7	31	25587	9½	78	12830
2⅛	00	87441	4⅝	09	01515	7⅛	32	96038	9⅝	81	25307
2¼	01	03797	4¾	09	76604	7¼	34	72574	9¾	84	46006
2⅜	01	22075	4⅞	10	55751	7⅜	36	55305	9⅞	87	75035
2½	01	42383	5	11	39062	7½	38	44336	10	91	12500

In this Table you have eight Columns; in the firſt, third, fifth, and ſeventh Columns, there are the Inches, and eight Parts of Inches that the Diameter of the Ball doth contain, and are marked with the Letter B: And in the ſecond, fourth, ſixth, and eighth Columns, you have the Weight of theſe Diameters of Iron Ball in Scots Weight; under Li. you have Pounds, and under Parts you have the Decimal Parts of Pounds.

Tables for Iron Ball, whoſe Diameters being meaſured with Scots Inches, are exactly calculated for Scots Weight, in Pounds, Ounces and Drams, from eight parts to eight parts of Scots Inches, unto Ten Inches.

B	Li.	Ou.	Dr	B	Li.	Ou.	Dr.	B	Li.	Ou.	Dr.
1	00	01	07	4	05	13	05	7	31	04	02
1⅛	00	02	01	4⅛	06	06	05	7⅛	32	15	06
1¼	00	02	14	4¼	06	15	06	7¼	34	11	10
1⅜	00	03	13	4⅜	07	10	01	7⅜	36	08	14
1½	00	04	15	4½	08	04	14	7½	38	07	02
1⅝	00	06	04	4⅝	09	00	04	7⅝	40	06	06
1¾	00	07	13	4¾	09	12	04	7¾	42	06	11
1⅞	00	09	10	4⅞	10	08	15	7⅞	44	08	01
2	00	11	11	5	11	06	04	8	46	10	08
2⅛	00	14	00	5⅛	12	04	05	8⅛	48	07	13
2¼	01	00	10	5¼	13	02	15	8¼	51	02	11
2⅜	01	03	09	5⅜	14	02	07	8⅜	53	08	08
2½	01	06	13	5½	15	02	09	8½	55	15	06
2⅝	01	10	06	5⅝	16	03	08	8⅝	58	07	08
2¾	01	14	05	5¾	17	05	03	8¾	61	00	12
2⅞	02	02	10	5⅞	18	07	10	8⅞	63	11	03
3	02	07	06	6	19	10	15	9	66	06	14
3⅛	02	12	08	6⅛	20	15	00	9⅛	69	03	13
3¼	03	02	01	6¼	22	03	15	9¼	72	01	15
3⅜	03	08	01	6⅜	23	09	12	9⅜	75	01	06
3½	03	14	08	6½	25	00	06	9½	78	02	01
3⅝	04	05	07	6⅝	26	07	15	9⅝	81	04	01
3¾	04	12	14	6¾	28	00	06	9¾	84	07	06
3⅞	05	04	13	6⅞	29	09	12	9⅞	87	12	00

In this Table you have ſix Columns; in the firſt, third, and fifth Columns, there are the Inches, and eight parts of Inches, that the Diameter of the Ball doth contain, and are marked with the Letter B; and in the ſecond, fourth, and ſixth Columns, you have the Weight of theſe Diameters of Iron Ball in Scots Weight; under Li. you have Pounds, under Ou. Ounces, and under Dr. Drams.

Tables for Iron Ball, whoſe Diameters being meaſured with Scots Inches, are exactly calculated for Engliſh Weight; from Eight Parts to Eight Parts of Scots Inches, unto Ten Inches: Decimally.

B	Li.	Parts.	B	Li.	Parts.	B	Li.	Parts.	B	Li.	Parts.
⅛	00	00020	2⅝	01	85429	5⅛	13	79976	7⅝	45	44746
¼	00	00160	2¾	02	13200	5¼	14	83433	7¾	47	71942
⅜	00	00541	2⅞	02	43615	5⅜	15	91936	7⅞	50	06587
½	00	01 .81	3	02	76792	5½	17	05604	8	52	48800
⅝	00	02503	3⅛	03	12853	5⅝	18	24558	8⅛	54	98702
¾	00	04325	3¼	03	51917	5¾	19	48918	8¼	57	56413
⅞	00	06868	3⅜	03	94105	5⅞	20	78805	8⅜	60	22052
1	00	10252	3½	04	39536	6	22	14337	8½	62	95741
1⅛	00	14596	3⅝	04	88331	6⅛	23	55637	8⅝	65	77600
1¼	00	20023	3¾	05	40610	6¼	25	02823	8¾	68	67746
1⅜	00	26650	3⅞	05	96493	6⅜	26	56016	8⅞	71	66303
1½	00	34599	4	06	56100	6½	28	15335	9	74	73389
1⅝	00	43990	4⅛	07	19552	6⅝	29	80902	9⅛	77	89125
1¾	00	54942	4¼	07	86968	6¾	31	52836	9¼	81	13631
1⅞	00	67576	4⅜	08	58468	6⅞	33	31257	9⅜	84	47027
2	00	82012	4½	09	34174	7	35	16286	9½	87	89433
2⅛	00	98371	4⅝	10	14204	7⅛	37	08042	9⅝	91	40970
2¼	01	16772	4¾	10	98680	7¼	39	06646	9¾	95	01757
2⅜	01	37335	4⅞	11	87720	7⅜	41	12218	9⅞	98	71914
2½	01	60181	5	12	81445	7½	43	24878	10	102	51562

In this Table you have eight Columns; in the firſt, third, fifth, and ſeventh Columns, there are the Inches, and eight Parts of Inches that the Diameter of the Ball doth contain, and are marked with the Letter B: And in the ſecond, fourth, ſixth, and eighth Columns, you have the Weight of theſe Diameters of Iron Ball in Engliſh Weight; under Li. you have Pounds, and under Parts you have the Decimal Parts of Pounds.

Tables for Iron Ball, whoſe Diameters being meaſured with Scots Inches, are exactly calculated for Engliſh Weight, in Pounds, Ounces, and Drams, from eight parts to eight parts of Scots Inches, unto Ten Inches.

B	Li.	Ou.	Dr.	B	Li.	Ou.	Dr.	B	Li.	Ou.	Dr.
1	00	01	10	4	06	09	00	7	35	02	10
1⅛	00	02	05	4⅛	07	03	02	7⅛	37	01	05
1¼	00	03	03	4¼	07	13	15	7¼	39	01	01
1⅜	00	04	04	4⅜	08	09	06	7⅜	41	01	15
1½	00	05	09	4½	09	05	07	7½	43	04	00
1⅝	00	07	01	4⅝	10	02	04	7⅝	45	07	03
1¾	00	08	13	4¾	10	15	13	7¾	47	11	08
1⅞	00	10	13	4⅞	11	14	01	7⅞	50	10	01
2	00	13	02	5	12	13	00	8	52	07	13
2⅛	00	15	12	5⅛	13	12	13	8⅛	54	15	13
2¼	01	02	11	5¼	14	13	06	8¼	57	09	00
2⅜	01	06	00	5⅜	15	14	11	8⅜	60	03	08
2½	01	09	10	5½	17	00	14	8½	62	15	05
2⅝	01	13	11	5⅝	18	03	15	8⅝	65	12	07
2¾	02	02	02	5¾	19	07	13	8¾	68	10	13
2⅞	02	07	00	5⅞	20	12	10	8⅞	71	10	10
3	02	12	05	6	22	02	05	9	74	11	12
3⅛	03	02	01	6⅛	23	08	14	9⅛	77	14	04
3¼	03	08	05	6¼	25	00	07	9¼	81	02	03
3⅜	03	15	01	6⅜	26	08	15	9⅜	84	07	08
3½	04	06	05	6½	28	02	07	9½	87	14	05
3⅝	04	14	02	6⅝	29	12	15	9⅝	91	06	09
3¾	05	06	08	6¾	31	08	07	9¾	95	00	04
3⅞	05	15	07	6⅞	33	05	00	9⅞	98	11	08

In this Table you have ſix Columns, in the firſt, third, and fifth Columns, there are the Inches and eight parts of Inches, that the Diameter of the Ball doth contain, and are marked with the Letter B; and in the ſecond, fourth, and ſixth Columns, you have the Weight of theſe Diameters of Iron Ball in Engliſh weight; under Li. you have Pounds, under Ou. Ounces, and under Dr Drams.

CHAP. XXIII.

The Uſe of the preceding Tables.

Uſe of the Tables of Iron Ball, meaſured with Scots Inches.

IF the Diameter of an Iron Ball be meaſured with Scots Inches, I would know what the ſame Ball weigheth in Engliſh Weight.

Example.

There is an Iron Ball, whoſe Diameter is $5\frac{1}{2}$ Scots Inches, I demand what the ſame Ball weighs in Engliſh Weight.

Look in the Table in *pag.* 98. under B in the fiſth Column, where you find $5\frac{1}{2}$ Inches, and right againſt it, in the ſixth Column, you have 17 pound and $\frac{056}{1000}$ pounds, which is the juſt weight of the ſame Ball.

Or otherwiſe, Look in the Table in *pag.* 99. under B, in the third Column, where you find $5\frac{1}{2}$ Inches, and right againſt it, in the fourth Column, you have 17 pounds, 00 ounces, and 14 drams, which is alſo the juſt Weight of the ſame Ball.

Or, If the Diameter of an Iron Ball be meaſured with Scots Inches, I deſire to know what the ſame Ball weigheth in Scots Weight.

Example.

There is an Iron Ball whoſe Diameter is $6\frac{1}{8}$ Scots Inches; I demand what doth the ſame Ball weigh in Scots Weight.

Look in the Table in *pag.* 96, under B, in the fifth Column, where you find $6\frac{1}{8}$ Inches; and right againſt it, in the ſixth Column, you have 20 pound and $\frac{938}{1000}$ parts of a pound, which is the juſt Weight of the ſame Ball in Scots Weight.

Or otherwiſe, Look in the Table in *pag.* 97. under B, in the third Column, where you find $6\frac{1}{8}$ Inches; and right againſt it, in the fourth Column, you have 20 pounds and

15 ounces, which is alſo the juſt weight of the ſame Ball in Scots Weight. And this I will aſſure you to be truth, becauſe I have calculated all theſe Tables with my own hand, and they are ſince reviſed and truly done, by the laborious pains of Mr. *Robert Webſter.*

An Inventory *of* Ordnance, Carriages, Powder, Shot, *and all Stores allowed on Board His Majeſty's Ships of all Rates, in Time of War, according to the Cuſtom of the Tower.*

	Names of Guns.	1ſt Rate	2d Rate	3d Rate	4th Rate	5th Rate	6th Rate
Braſs or Iron Ordnance for	Cannon of 7	22					
	Demy Cannon		22	24			
	Culvering	18	30	30			
	Demy Culvering	24			24	20	
	Saker	12	36	22	12	14	20
	Minion			4			4
	Falcon						
	24 Pounders	24			22		
	12 Pounders						
	8 Pounders						
	6 Pounders						
	3 Pounders		2		2	6	4
Ship Carriages, for	Cannon of 7	22					
	Demy Cannon		22	24			
	Culvering	18	30	30			
	Demy Culvering	24			24	20	
	Saker	12	36	22	12	14	20
	Minion			4			4
	Falcon						
	24 Pounders	24			22		
	12 Pounders						
	8 Pounders						
	6 Pounders						
	3 Pounders		2		2	6	

Round

	Names of Stores.	1ſt Rate	2d Rate	3d Rate	4th Rate	5th Rate	6th Rate
Round Shot, for	Cannon of 7	880					
	Demy Cannon		880	960			
	Culvering	720	1200	1200			
	Demy Culvering	960			960	800	
	Saker	480	1440	880	480	560	800
	Minion			160			160.
	Falcon						
	24 Pounders	960			880		
	12 Pounders						
	8 Pounders						
	6 Pounders						
	3 Pounders		80		80	240	240
	Pound Shot	6000	4000	3000	2000	500	
Dead-headed hammer'd Shot, for	Cannon of 7	132					
	Demy Cannon		132	144			
	Culvering	108	180	180			
	Demy Culvering	144			144	126	
	Saker	72				96	120
	Minion						
	24 Pounders	144			132		
	12 Pounders						
Tin Caſes fill'd with Muſquet Shot, for	Culvering						
	Dem. Culv.	240			240		
	Saker.	120	360	226	85	140	200
							20
Barrs of Iron		500	430	300	180	90	25
Hand Granadoes		200	140	100	70	40	
Fuzees for them		240	160	115	80	50	

Ladles

	Names of Stores.	1ſt Rate la ſp	2d Rate la ſp	3d Rate la ſp	4th Rate la ſp	5th Rate la ſp	6th Rate la ſp
Ladles & Spunges for	Cannon of 7	4 6					
	Demy Cannon		4 6	5 7			
	Culvering	3 4	6 9	6 9			
	Demy Culvering	4 7			4 6	3 5	
	Saker	3 4	7 10	4 6	3 4	3 5	4 6
	Minion			2 2			2 2
	24 Pounders	5 6			4 6		
	12 Pounders						
	3 Pounders		1 1		1 1	2 4	2 4
	Ladle Staves	50	40	34	24	14	08
	Cannon of 7	36					
	Demy Cannon		33	36			
	Culvering	27	45	45			
	Demy Culvering	36			36	30	
	Saker	20	54	33	18	21	30
	Minion			6			6
	24 Pounders	36			33		
	12 Pounders						
	3 Pounders		3		3	9	9
	Funnils of Tin	5	3		2	2	1
	Powder in Barrels	500	315	307	175	110	55
	Match, Hund. wt.	15	11	9	5	3½	2
	Snaphanſes	150	120	80	60	40	30
	Blunderbuſſes	10	8	5			
	Muſquetoons	10	8	5	8	6	4
	Piſtols, Pairs	50	30	20	16	10	8
	Bandaleers, Collars	50	30	26	20	15	10
	Cartouch Boxes	150	120	85	65	45	30
	Muſquet Rods	50	40	36	24	18	12
	Flints	5000	4000	3000	2000	1500	1000
	Long Pikes	50	36	24			
	Short Pikes	36	24	24	24	16	18
	¾ Pikes	36	24	24	24	16	
	Bills	18	12	12	10	6	4
	Hatchets	70	60	45	30	15	12
	Swords	70	60	40	30	20	15

Hangers

	Names of Stores.	1ſt Rate	2d Rate	3d Rate	4th Rate	5th Rate	6th Rate
	Hangers	70	60	40	30	20	15
	Muſquet Shot, Hun. wt.	15	11	8	6	3½	2
	Piſtol Shot, Hund. wt.	3½	2½	1½	1	3¾	½
	Sheet Lead, Hund. wt.	1	3½	2½	2	1½	1
	Aprons of Lead	100	90	80	60	40	30
	Crows of Iron	100	90	80	60	40	30
	Tackle Hooks, pairs	60	50	40	30	20	15
	Ladles Hooks, pairs	70	60	50	40	30	20
	Linch-pins, pairs	55	45	40	30	20	10
	Port Hooks	100	90	70	50	40	30
	Spikes	400	300	250	200	150	100
	Forelock Keys, pairs	150	100	90	70	50	40
	Sledges	4	3	2	2	1	1
	Great melting Ladles	3	2	2	2	1	1
	Small Ditto	4	3	2	2	1	1
Nails of Sorts.	40 penny	500	300	250	100		
	30*d*	500	400	350	200		
	20*d*	400	400	400	400	350	200
	10d	1000	1500	1000	500	500	300
	6*d*	3000	2500	1500	1500	500	300
	4*d*	-	1000	1000		500	
	3*d*	2500	2000	1000			500
	2*d*	5000	4500	3000		1500	1000
	Copper-Nails	800	500	400	300	150	100
	Beds	120	100	90	70	45	35
	Coynes	240	200	180	140	90	70
Extrees	Can. & Dem. Can.	8	5	5	4		
	Culv. & Dem. Culv.	8	5	4	4	4	
	Saker & Minion	8	5	3	2	2	4
	Trucks Ordinary, pairs	15	10	8	5	3	
	Ditto Extraordin. pairs	15	10	8	5	2	
	Tampeons, Great	1000	400	400	400	100	
	Ditto Small	1000	300	300	100	150	200
Heads & Rammers	Great pairs	50	30	30	25		
	Small pairs	40	20	15	10	25	12
	Formers, Great	10	5	4	4	2	

Formers

Names of Stores.	1ſt Rate	2d Rate	3d Rate	4th Rate	5th Rate	6th Rate
Formers, Small	8	5	4	3	3	4
Budge Barrels	7	5	4	3	2	2
Tann'd Hides	24	15	12	8	6	4
Sheep-skins, Dozens	8	5½	5	4	18	1½
Baskets	50	40	36	24	2½	12
Spare Hoops, pairs	4½	3	2½	2	1	½
Canvas, Ells	200	100	90	80	50	50
Royal Paper, Rheams	15	10	9	7	4	2½
Fine Paper, Rheams	2½	2	2	1	½	8q
Oyl, Gallons	10	7	6	4	1½	½
Tallow, hundred wt.	3½	2½	2	1½	3	
Starch, Pounds	24	15	12	10	8	5
Needles, Dozens	24	15	12	10	8	5
Thread, Pounds	24	15	12	10	8	5
Lanthorns, ordinary	10	8	06	5	4	3
Dit. ex. Tin 1 to each Ship						
Dark	3	2	2	1	1	1
Muſcovia Lights	5	3	2	2	2	2
Ditto extraordinary	4	3	2	2		
Wad Hooks	20	15	12	8	5	3
Hand Crow Leaves	140	110	100	75	50	40
Rope Sponges	100	90	80	60	40	30
Powder Horns	150	120	100	80	50	40
Priming Irons	150	120	100	80	50	40
Linſtocks	25	20	15	10	6	4
Marlin, pounds	80	60	56	45	30	20
Twine, pounds	25	15	12	10	5	3
Wyer, pounds	20	10	10	8	4	3
Hand Screws	3	2	2	1	1	
Tarr'd Rope, of 7 Inches, Coyle	1					
6½	1	1	1			
6				1		
5½	1	1	1			
5				½		
4½	1		1		½	
4		1		½		½
3½	1				½	
3	3½	3½	3½	2½	1	½
2½	3	2		1	½	½
2	2	2	2½	1	½	½

Names of Stores.	1ſt Rate	2d Rate	3d Rate	4th Rate	5th Rate	6th Rate
Breechings	100	90	80	60	40	30
Tackles	200	180	160	120	80	60
Port Tackles, Coyle	7½	6½	5	2½	1	1
Junk for Wads, Hd. wt.	7	50	45	30	20	15
Cartridges of Parchment.						
Cannon of 7	660					
Demy Cannon		660	720			
Culvering	540	900	900			
Demy Culvering	480			480		
Saker	240	720	440	240	320	400
Minion			80			
24 Pounders	720			660	400	
12 Pounders						
3 Pounders		40		40	80	80
Smiths Vices	2	1	1	1	1	
Putty and Emery, pounds	5	3	2½	2	1	1
Files of Sorts, Dozens	1½	1	1	6	4	4

CHAP.

CHAP. XXIV.

The Order and Neceſſaries for Guns to March by Land, they having ſix Demi-Cannons, ſix Sakers, or Demi-Culverings, with two Whole-Cannons, beſides their Field-Ordnance.

BEfore the Train doth march, there goeth out Pioneers, each of which is furniſhed with either a Shovel, Scoop, Pickax, Crow or Handſpike; having for their Commanders, a Captain, Lieutenant, and two Corporals, with a Drum to every Company; who are to make plain the Way for the Cannon.

After them, *Firſt*, Follow the ſix Sakers, or Demi-culverings, drawn with their reſpective Horſes, with their Proviſion of Ball in Waggons, and their Powder in Waggons, beſides there muſt be at the Rear of the Cannon, if any whelm, help ſufficient to mount them again.

Next follow them ſix Demi-Cannon, with their Shot and Powder conform; then two whole Cannon, with their Powder and Ball accordingly.

Then the Carriage of Ladles, Sponges, and Rammers, Match, Crows and Handſpikes, and Budge-Barrels: Theſe, beſides the Field-Peeces for the reſpective Regiments, take a great many Horſes, Waggons, and Men for their Attendants.

Now when the Cannons are on their March, every Gunner to his reſpective Place, muſt march at the right ſide of his Peece, and by them their Harbingers, who take Notice of all the Ropes, and other Proviſions for Draught, and help them if defective; and alſo to ſee that the Axtrees be well ſoaped or tallow'd, that thereby the Train may march without Stop. The Waggon-Maſter muſt have Spare-Horſes by his Draught, if any fail either in Waggons, or in Draughts of the Ordnance.

Several have given Rules for ſo many Horſes to a Peece of ſuch a Weight; as thus, every 500 ℔ of Metal for a Horſe-Draught; where the Guns alone, beſides the Carriages, muſt have 120 Horſes: So I reckon for Guns, Carriages and Spare-Horſes, there will be 180 Horſes: Now for Powder, Ball, and other Proviſions, 100 Horſes more with Waggons, beſides Waggons for the Officers.

This is ſuppoſed to be for ſo many Cannon in fine plain Way; but the Horſes in every Country are not all alike: for I have been drawing Cannon, and allowed but to every Horſe 350 ℔, and hardly able to perform; but ſure it is, where Horſes are to be preſs'd, there need no Halt to be made for Draught, if the Conductors be provident. But if there ſhould fortune Cannon to be drawn in Places where Horſes or Oxen (for if you order a Yoke of Oxen for a Horſe-Draught it will be equal) are not to be found: Therefore I will ſet down a general Rule, how theſe Guns may be drawn by the Strength of Men. And the Calculation ſhall be made for the forenamed fourteen Guns; by which may be reckon'd any other Draught having the Weight.

Firſt, It is conceived an indifferent Man will draw 100lb. for his part, (but on a plain Way); therefore for ordinary, I do allow a Man to draw 80 pound weight: And you will find, counting the Weight of theſe 14 Peeces thus: The Cannon 7000 ℔ a-piece, is 14000 ℔ for them two; then the Demi-Cannon 4500 ℔, and theſe ſix are 27000 ℔; for the ſix Demi-culverings 3200 ℔ a-piece, and theſe will weigh 19200 lb. which is in all 60200 lb. which Sum being divided by 80, (the Pounds of Draught for one Man) will make 752 Men to draw the fourteen Peeces of Cannon. Now theſe 752 Men to employ with Diſcretion and good Order, that every Man may do his Endeavour, you are to make faſt your Ropes in this Manner, on either Side of the Carriage; before on the Hacks one Rope, and on the middle of the Bolt or Breſt-band one: And upon every Rope ſhall be ſo many Ropes ſo made faſt, as every Man may have 2½ Foot diſtance one from another; ſo that the Draught Ropes for a Demi-culvering muſt be 17 Fathom long:

Now for the Demi-Cannon and Cannon, they may be reckoned by their Proportion; ſo the Men are ſet to work as the Figure hereby doth ſhew.

This will be thought a new Invention, but I uſed the ſame in my Lord *Middleton*'s Service from *Aberdeen* to *Fyvie*, where I cauſed them to make theſe Sled-feet, as you ſee faſt to the Carriage, in this Manner: Near to the Breech of the Peece there is a Bolt, whereon the end of the Sled-foot is; and under it, at the Foot-end of the Carriage, a Square-hack to lay over the Sled-foot, and then a Rope through the Sled-foot: And a Man or two thereby ſhall ſteer a Gun by a Height or Hole, in the Way where ſhe is to be drawn, ſo that many times it ſaves the Guns from falling over.

And when you are to meet your Enemy, or make uſe of your Guns, you may liſt up your Sled-feet, and lay them all along the Side of the Carriage, in Manner as you ſee; on a Hack where they do not trouble, and unhacking the Ropes from the Hacks before, you may uſe your Guns at Pleaſure.

CHAP. XXV.

By knowing the Weight of one Peece of Ordnance True-bored, to find the Weight of another True-bored Peece, being of the ſame Metal.

BEcauſe it falleth out ſometimes, that in a Fort or Ship are Guns, not having their Weight deſcribed upon them, therefore, in ſuch Occaſions, not to let the Gunner be to ſeek, but that he may give her Weight without great Trouble, I ſhall here ſet down ſome Examples, whereby the Gunner may with Eaſe find the Weight of any great Ordnance, whereby he may be able to ſhew, what Store of Horſes or Men are competent to draw theſe Ordnance, if Occaſion require.

Theſe Examples and Rules I intended to have given by a Gauge-Rule; and becauſe theſe Ways are more eaſy to do, and quicker diſpatched, I ſhall only take by the Way to let you know, that I will admit there is a Braſs Saker, weighing 1900 lb. weight; and as it is given out in other Queſtions, ſhe is $3\frac{3}{4}$ Inches in the Diameter of the Bore: Now it is commonly found, theſe Guns are about the Breech, meaſuring at the Touch-hole, 9 Diameters of the Bore; I ſay then, if I bring $3\frac{3}{4}$ Inches all into Quarters, then I have 15 Quarters; with which I multiply the 9 Diameters of her Breech, and I find them 135 Quarters; which dividing by 4, I bring again to whole Inches, and find $33\frac{3}{4}$, which we will here call 34 Inches, for the Circumference of her Breech: Then I ſay by the *Rule of Three*, As 22 is to 7, ſo is 34 to $10\frac{9}{11}$ Inches.

The Work.

```
22      7      34     (1
                7     23(8 / 10 18/22 = 9/11 Inches.
             ----     22 2
              238     2
```

This $10\frac{9}{1}$ of Inches is the Diameter of that Saker; if ſhe be True-bored ſhe is True-fortified: And ſuch are the only Guns to make choice of, for finding by their Weight the Weight of any other Braſs Peece: Therefore, I ſay,

Example.

If a Gun of 11 Inches Diameter at the Chamber weighs 1900 lb. What ſhall a Peece of 18 Inches Diameter weigh?.

Thus by the Table of Logarithms.

The Logarithm of 11 Inches, is	1,041393
The Logarithm of the greater, 18 Inches, is	1,255272
Difference increaſing	213879
	3
The Triple whereof is	641637
The Weight of the known Peece is 1900 lb.	3,278754
Sum is	3,920391

which is the Logarithm of 8325 lb. for the Weight of the great Gun.

Here you ſee that this operateth well by the Table of Logarithms, and the Weight of the Peece is found to be 8325 lb. Now to find the ſame by the Line of Numbers on the Scale, you are to place one Foot of your Compaſſes in 11, and the other in 18; keeping the Compaſſes at the ſame Extent, ſet one Foot in 1900, and then triple turning the Compaſſes, the laſt Foot will touch at 8325, as before.

Another Example.

Alſo there is a Peece, I know not what her Weight is; but I find the Diameter of this Peece to be $8\frac{1}{4}$ Inches; and I place the Work to find her Weight as beſore.

Behold the Work.

The Diameter of the known Peece is 11 Inches — 1,041393

The Logarithm of the Diameter of the other $8\frac{1}{4}$ - 0,942008

Difference decreasing ——————— 99385

3

Triple of the Difference is ——————— 298155

which ſubſtracted from the Logarithm of 1900 — 3,278754

Reſts ——————————— 2,980599

which is the Logarithm of $956\frac{1}{3}$ lb. for the Weight of the leſſer Peece, which was required.

The Weight thus ſound by Logarithms, you will find the like by the Line of Numbers, if you extend your Compaſſes from 11, the known Diameter, to $8\frac{1}{4}$, the Diameter of the Peece whoſe Weight you would have; the ſame Extent three times from 1900 down the Scale, will reach to $956\frac{1}{3}$.

This former Work you may find on the Line of Numbers, if you place one Foot in 9, the Diameter of the Bore that begirts the Peece at the Touch-hole, and the other Foot in 7, which is moſt near the Diameter that begirts the other Peece, and the Compaſſes at the ſame Extent, place one Foot in 1900, the Weight of the known Peece, and three times turned downward, will light on $956\frac{1}{3}$, as before.

CHAP.

CHAP. XXVI.

By knowing the Weight of one Peece of Iron Ordnance, to find the Weight of another Peece of Iron Ordnance.

SUppoſe an Iron Saker of 3¾ Inches Diameter of the Bore, this Peece weigheth 1600 lb. I find all ſuch Peeces to have 11 Diameters of the Bore about the Breech; for which Cauſe I work as before, and bring 3¾ into Quarters, which I multiply by 11, the Diameters of the Bore about the Breech, and I find 165, which I divide by 4, to bring again into Inches, and the Quotient is 41: Then I ſay, by the Rule of *Archimedes*, As 22 is to 7, ſo is 41 to 13 $\frac{1}{22}$ Inches.

$$\begin{array}{cccc} 22 & 7 & 41 & \\ & & 7 & 287 \\ \hline & & 287 & \end{array}$$

The Fraction is ſo ſmall not to be valued.

So that I find 13 Inches to be the Diameter of an Iron Saker, whoſe Weight is 1600 lb. and that the ſame is a True-bored, True-Fortified Peece: Now there is an Iron Peece whoſe Weight I know not, but I find the Diameter of that Peece at the Touch-hole, or charged Cylinder, to be 21 Inches.

To find the Weight of this Peece Logarithmically.

Example.

I ſay, a Peece of Ordnance of Iron, of 13 Inches Diameter, weighing 1600 lb. What ſhall an Iron Peece of 21 Inches Diameter weigh?

The Work will ſtand thus.

The Logarithm of 13 Inches, is ———— 1,113943
The Logarithm of 21 Inches, is———— 1,322219
Difference increaſing ———— 208276
3
Triple of the Difference is ———— 624828
The Weight of the known Peece 1600, is —— 3,204119
Sum is ———— 3,828947

Which is the Logarithm of 6744 ℔. for the Weight of the Peece inquired.

If you will work by the Line of Numbers on the Scale, you will find it near the ſame; for if you place one Foot of your Compaſſes in 13 Inches the Diameter of the known Peece, and the other in 21 Inches the Diameter of the Peece whoſe Weight you deſire to know; keeping your Compaſſes at the ſame Extent, ſet one Foot in 1600, the Weight of the known Peece, turning your Compaſſes three times up the Scale, and you will find the third Extent will reach 6744, which is the Weight of the Peece required.

Another Example.

There is alſo a Peece of Iron Ordnance, whoſe Diameter I find in the charged Cylinder to be 8 ¼ Inches; the Queſtion is, to find her Weight.

The Log. of the known Peece, 13 Inches, is — 1,113943
The Log. of the other Peece, 8 ¼ Inches, is — 0,916454
Difference decreaſing ———— 0,197489
3
Triple of the Difference is ———— 0,592467
Which ſubtracted from the Log. of 1600 —— 3,204119
Reſts ———— 2,611652

Which is the Logarithm of 409 ℔. for the Weight of the Peece inquired.

Finding here the Weight of this Peece to be 409 ℔, you ſee it followeth, that great or ſmall Ordnance their Weight may be found; yet for variety we will have another Example.

Example.

I will admit there is a Peece found, whoſe Diameter is 10 ½ Inches; and the Weight of this Peece I demand.

The Log. of the known Peece, 13 Inches, is —— 1,113943
The Log. of the other Peece, 10 ½ Inches, is —— 1,021189
Difference decreaſing —————————— 0,092754
3
Triple of the Difference is ←—————— 0,278262
Which being ſubſtracted from the Log. of 1600 —— 3,204119
Reſts —————————————— 2,925857

Which is the Logarithm of 843 ℔. for the Weight of the Peece inquired.

This and the former is found on the Line of Numbers, if you extend your Compaſſes from 13 to 8 ¼; and with the ſame Extention turned three times down the Scale, you have 409 ℔. If you extend from 13 to 10 ½, and with the ſame Extent from 1600, three times turned down finds 843 ℔. for the Weight of the Peece inquired. And ſo much for the finding the Weight of Ordnance, thereby to provide what Horſes, Oxen, or Men are able to draw them. As the Figure here demonſtrates.

F I N I S.